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LIST OF PLATES.

ERRATA.

Page 116, line 22, *for* 1855 *read* 1815.
Pages 161, 164, 165, *for* Plate V. *read* Plate VI.
Page 238, line 46, *after the word* " annually " *insert* " on the third Wednesday ".

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EDITED BY

JAMES GLAISHER, F.R.S.

1871, NOVEMBER 15.

JOHN W. TRIPE, M.D., PRESIDENT, in the Chair.

The name of one Candidate for admission into the Society was read.

I. *On the Direction of the Wind at the Royal Observatory, Greenwich, in the Ten Years ending December* 1870. By JAMES GLAISHER, F.R.S.

TEN years since, I presented to the Society a paper on the Direction of the Wind in the Twenty Years ending December 1860. I have now the honour of presenting another paper on the observations made at Greenwich in the Ten Years ending December 1870. The directions of the wind used are those recorded by Osler's self-registering anemometer, and therefore show the direction of the current of air at a point about 70 feet above the ground, and 200 feet above the level of the sea.

As in the preceding paper it was pointed out that there had been a marked difference in the general direction of the wind in the years 1848 to 1856 from those preceding 1848 and those following 1856, I formed a similar Table of prevailing direction in each month in a manner similar to those formed for the twenty years ending 1860, and which is as follows:—

TABLE I. Showing the prevailing Direction of the Wind at Greenwich, in every Month from January 1861 to December 1870.

Years.	January.	February.	March.	April.	May.	June.
1861.	S.W.	S.W.	S.W., W.	N.E., E.	N., N.E.	N.E., S.W.
1862.	S.W.	variable	S.W.	S.W.	S.W., W.	S.W., W.
1863.	S.W.	S.W.	variable	S.W.	N.E.	S.W., W.
1864.	S.E., S.W.	N., S.W.	variable	variable	N.	S.W.
1865.	S.W., W.	S.W.	N.	S.W.	S.W.	N.
1866.	S.W., W.	S.W., W.	variable	E., S.W.	variable	S.W., W.
1867.	S.W.	S.W.	N.E.	S.W.	E., S.W.	N., S.W.
1868.	S.W.	S.W., W.	S.W., W.	S.W., N.	S.W.	S.W.
1869.	S., S.W.	S.W.	N., N.E.	N.E., S.W.	N.E., S.W.	variable
1870.	variable	N.E., S.	N.E.	S.W.	S.W.	S.W., W.
Years.	**July.**	**August.**	**September.**	**October.**	**November.**	**December.**
1861.	S.W.	S.W., W.	S.W., W.	N.E., S.W.	S.W.	N.E., S.W.
1862.	S.W., W.	S.W.	N.E., S.W.	S.W.	variable	S.W., W.
1863.	variable	S.W.	S.W.	S.W.	S.W.	S.W., W.
1864.	S.W.	variable	S.W.	variable	S.W.	variable
1865.	S.W., W.	S.W., W.	S.W.	variable	S.W.	S.W.
1866.	variable	S.W., W.	S.W.	N.E., S.W.	S.W.	S.W.
1867.	S.W.	S.W.	S.W.	S.W.	N., S.W.	variable
1868.	N., S.W.	S.W.	N.E., S.W.	S.W., W.	N., N.E.	S.W.
1869.	S.W.	N.E., S.W.	S.W., W.	variable	S.W., W.	N., S.W.
1870.	S.W., W.	N., N.E.	S.W.	S.W.	S.W.	N.E.

By collecting these several directions together in each year, we learn that the prevailing direction of the wind was—

In the year 1861:—
S.W. for 7 months.
N.E. for 2½ months.
W. for 1½ month.
E. for ½ month.
N. for ½ month.

In the year 1862:—
S.W. for 7½ months.
W. for 2 months.
N.E. for ½ month.
Variable for 2 months.

In the year 1863:—
S.W. for 8 months.
N.E. for 1 month.
W. for 1 month.
Variable for 2 months.

In the year 1864:—
S.W. for 5 months.
N. for 1½ month.
S.E. for ½ month.
Variable for 5 months.

In the year 1865:—
S.W. for 7½ months.
N. for 2 months.
W. for 1½ month.
Variable for 1 month.

In the year 1866:—
S.W. for 6 months.
W. for 2 months.
E. for ½ month.
N.E. for ½ month.
Variable for 3 months.

In the year 1867:—
S.W. for 8½ months.
N.E. for 1 month.
E. for ½ month.
N. for 1 month.
Variable for 1 month.

In the year 1868:—
S.W. for 8 months.
N. for 1½ month.
W. for 1½ month.
N.E. for 1 month.

In the year 1869:—
S.W. for 5½ months.
N.E. for 2 months.
W. for 1 month.
S. for ½ month.
N. for 1 month.
Variable for 2 months.

In the year 1870:—
S.W. for 6 months.
N.E. for 3 months.
S. for ½ month.
N. for ½ month.
W. for 1 month.
Variable for 1 month.

Treating the observations in this general way, we find that the S.W. appears to have been the prevailing wind on the average in 7 months of each year, being identical in value to that found from the years 1841 to 1860, the observations being treated in a similar way.

In the years 1863, 1867, and 1868 it was the prevalent wind in 8 months, and in the year 1864 and 1866 in 5 or 6 months only.

The S. wind in these ten years was the prevalent wind for about ½ a month in each of the years 1869 and 1870.

The S.E. wind was also prevalent for about ½ a month in the year 1864. This wind was less frequent after the year 1858 than previously.

The E. was the prevalent wind for about ½ a month in the years 1861, 1866, and 1867, and has been more prevalent than in the years before 1861.

The N.E. wind was prevalent, upon the average, somewhat more than 1 month per year, being less frequent than in the years 1841 to 1860.

The N. was, on the average, the prevailing wind 1 month in the years 1861 to 1870, showing a marked increase from the years previous to 1861.

The N.W. wind was not the prevailing wind for a single month in these ten years, showing as marked a decrease as the N. wind had shown an increase.

The W. wind was, on the average, prevalent for ½ a month, showing a considerable increase over the results, as found previous to the year 1861.

But these results are deceptive, and of no practical value, being based on the prevailing winds only, to the exclusion of all others; yet in their broad features they are interesting, when compared with the results from other places similarly found, and as exhibiting marked difference in the general direction of the wind in different years; they are also valuable when compared with results deduced from self-registering anemometers, simultaneously recorded, the difference exhibiting the amount of error introduced by the use of prevailing winds alone, and hence the probable amount of error at stations where instruments are not used.

The much more valuable, but far more laborious discussion, is that based upon instrumental records, which include every variation of direction, and the exact time of continuance of every wind. The following results are entirely based upon the self-registering traces by Osler's anemometer, the action of which will now be explained.

A large vane, which is turned by the wind, and from which a vertical spindle proceeds down nearly to the table in the north-western turret of the ancient part of the Observatory, gives motion by a pinion upon the

spindle to a rackwork carrying a pencil. This pencil makes a mark upon a paper fixed to a board, which is moved uniformly in a direction transverse to the direction of the rack-motion. The movement of the board is affected by means of a second rack connected with the pinion of a clock. The paper has lines printed upon it corresponding to the positions which the pencil must take when the direction of the vane is N., E., S., or W.; and also has transversal lines corresponding to the positions of the pencil at every hour.

The hours of prevalence of every wind were thus self-recorded, and on every day between midnight and midnight, the number of hours of continuance of each wind, referred to eight points of the compass, were extracted; and in this way the total number of hours of each wind on every day from 1861, January, to 1870, December, became known. These were then formed into monthly Tables, of which the following two, the one for January 1861, and the other for January 1862, are specimens.

The first entry in this Table, viz. N.E. 11, shows that during the day the wind blew from the N.E. for 11 hours; it is not to be inferred that it did so continuously, but only that 11 hours is the total time during which the air passed from the N.E. during the day.

By comparing these two Tables together, it will be seen how different the two months are: in the one there was the greatest number of nearly calm hours in the whole series in any month, whilst in the other, there was not one hour which could be designated as calm, or nearly so.

By taking the sums under each direction in every month, as shown in these two Tables, the numbers in the Tables 1861 to 1870 were formed:—

Month and Day.	Direction of the Wind, as deduced from Osler's Anemometer.								
	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
1861.	.								
January 1	...	11	...	...	...	9	2	2	
„ 2	...	24							
„ 3	...	...	...	...	...	...	...	...	24
„ 4	...	...	...	...	...	...	...	...	24
„ 5	...	...	...	17	...	...	...	...	7
„ 6	10	5	...	...	...	...	...	4	5
„ 7	2	...	...	...	...	...	...	7	15
„ 8	...	...	...	...	6	...	...	...	18
„ 9	...	...	...	...	...	...	...	...	24
„ 10	...	...	...	...	...	...	...	...	24
„ 11	...	...	...	...	...	13	...	...	11
„ 12	...	...	...	. .	...	24			
„ 13	...	...	...	...	10	6	...	...	8
„ 14	...	...	11	1	...	...	...	...	12
„ 15	...	...	24						
„ 16	...	24							
„ 17	...	...	...	...	...	...	...	...	24
„ 18	...	...	...	...	...	...	...	...	24

Month and Day.	Direction of the Wind, as deduced from Osler's Anemometer.								
	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
1861.									
January 19	...	...	...	...	...	12	...	2	10
„ 20	...	...	...	...	...	24			
„ 21	...	...	...	...	...	24			
„ 22	...	...	...	...	...	24			
„ 23	...	...	...	...	...	24			
„ 24	...	...	...	...	10	14			
„ 25	...	...	...	...	...	24			
„ 26	...	...	...	...	...	10	14		
„ 27	...	...	...	...	3	17	4		.
„ 28	...	...	...	...	...	24			
„ 29	...	...	...	...	...	...	...	...	24
„ 30	...	...	...	...	...	12	...	...	12
„ 31	...	...	...	...	18	6			
Total	12	64	35	18	47	267	20	15	266
1862.									
January 1	5	18	...	...	...	...	1		
„ 2	...	24							
„ 3	...	...	2	...	...	9	11	2	
„ 4	10	...	...	...	...	...	5	9	
„ 5	13	...	...	...	...	...	7	4	
„ 6	4	...	...	...	...	4	10	6	
„ 7	...	...	...	...	...	24			
„ 8	...	...	...	...	...	19	5		
„ 9	...	...	...	...	...	24			
„ 10	...	...	...	...	...	19	5		
„ 11	...	...	...	...	...	15	9		
„ 12	...	...	...	...	2	15	4	3	
„ 13	...	...	...	...	2	5	8	9	
„ 14	...	8	4	3	7	2			
„ 15	...	18	6						
„ 16	...	...	9	8	7				
„ 17	...	...	...	24					
„ 18	...	...	...	24					
„ 19	...	...	...	24					
„ 20	...	...	...	24					
„ 21	...	...	18	6					
„ 22	...	...	...	6	8	10			
„ 23	...	...	...	8	11	5			
„ 24	...	...	...	...	3	21			
„ 25	4	...	...	...	...	13	4	3	
„ 26	...	...	...	...	4	20			
„ 27	...	...	...	4	19	1			
„ 28	...	...	...	...	10	14			
„ 29	...	...	...	...	...	12	12		
„ 30	...	...	...	...	...	...	24		
„ 31	...	...	...	...	...	...	24		
Total	36	68	39	131	73	232	129	36	

TABLES II. to XI. Showing the Number of Hours of prevalence of each Wind in every Month in each of the years 1861 to 1870, referred to the different Points of Azimuth.

TABLE II.

1861. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	12	64	35	18	47	267	20	15	266
February	25	87	14	55	79	262	47	42	61
March	36	2	13	0	7	249	265	128	44
April	85	139	211	8	0	34	48	66	129
May	188	175	75	28	14	75	70	40	79
June	99	138	117	36	17	202	81	30	0
July	8	2	16	26	46	440	157	49	0
August	5	5	0	5	33	353	268	71	4
September	62	25	3	20	66	318	194	32	0
October	23	178	104	137	89	182	18	10	3
November	42	42	4	6	14	373	157	82	0
December	22	162	88	81	69	148	78	58	38

During this year
The N. wind was most prevalent in May, and least in July and August.
„ N.E. „ „ „ May, „ March and July.
„ E. „ „ „ April, „ August.
„ S.E. „ „ „ October, „ March.
„ S. „ „ „ Feb., Oct., „ April.
„ S.W. „ „ „ July, „ April.
„ W. „ „ „ Mar., Aug., „ January and Oct.
„ N.W. „ „ „ March, „ October.
In the months of June, July, Sept., and Nov. there was not a calm hour.

TABLE III.

1862. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	36	68	39	131	73	232	129	36	0
February	60	84	95	133	50	78	116	24	32
March	43	160	80	63	29	278	48	19	24
April	12	174	6	64	10	285	125	35	9
May	7	88	62	68	31	225	180	63	20
June	70	35	3	14	15	249	210	103	21
July	43	13	7	23	14	319	282	43	0
August	66	116	21	42	7	252	144	39	57
September	30	197	64	52	49	228	55	12	33
October	47	63	62	48	15	291	165	24	29
November	179	134	40	23	65	110	72	10	87
December	49	·0	7	89	50	282	188	79	0

During this year
The N. wind was most prevalent in Nov., and least in April and May.
„ N.E. „ „ „ Sept., „ December.
„ E. „ „ „ Feb., „ June.
„ S.E. „ „ „ Feb., „ June.
„ S. „ „ „ Jan., „ April and August.
„ S.W. „ „ „ July, „ February.
„ W. „ „ „ July, „ March and Sept.
„ N.W. „ „ „ June, „ Sept. and Nov.
In the months of January, July, and Dec. there was not a calm hour.

Table IV.

1863. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	17	92	13	58	72	340	84	55	13
February	29	13	54	58	2	314	104	52	46
March	65	72	22	61	49	155	111	109	100
April	49	86	41	37	16	214	105	120	52
May	41	251	82	19	6	175	118	42	10
June	41	41	30	67	32	263	195	40	11
July	109	120	42	79	44	126	97	56	71
August	36	25	54	33	38	412	93	38	15
September	4	1	0	10	70	376	204	24	31
October	26	11	59	131	77	303	35	6	96
November	48	28	40	83	100	337	67	14	3
December	26	0	23	9	24	314	234	88	26

During this year

The N. wind was most prevalent in July, and least in September.
„ N.E. „ „ „ May, „ Sept. and Dec.
„ E. „ „ „ May, „ September.
„ S.E. „ „ „ October, „ Sept. and Dec.
„ S. „ „ „ November, „ February and May.
„ S.W. „ „ „ August, „ July.
„ W. „ „ „ December, „ October.
„ N.W. „ „ „ April, „ Oct. and November.

Table V.

1864. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	42	87	106	221	47	207	23	11	0
February	182	158	56	22	20	202	36	20	0
March	71	122	128	54	20	195	64	41	49
April	66	69	106	42	40	115	31	37	214
May	193	65	89	59	61	91	55	51	80
June	51	23	33	6	78	307	163	46	13
July	89	91	48	13	12	295	74	43	79
August	122	26	28	7	23	171	114	66	187
September	25	8	18	14	77	382	122	27	47
October	80	139	114	51	53	136	39	45	87
November	76	84	21	63	90	280	20	14	72
December	43	139	97	97	145	197	15	11	0

During this year

The N. wind was most prevalent in May, and least in September.
„ N.E. „ „ „ February, „ September.
„ E. „ „ „ March, „ September.
„ S.E. „ „ „ January, „ June and August.
„ S. „ „ „ December, „ July.
„ S.W. „ „ „ September, „ May.
„ W. „ „ „ June, „ December.
„ N.W. „ „ „ August „ January and Dec.

In the months of Jan., Feb., and Dec. there was not a calm hour.

Table VI.

1865. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	62	75	20	17	67	248	167	37	51
February	82	91	49	23	48	200	65	47	67
March	248	59	61	55	15	82	72	87	65
April	90	79	100	62	37	136	35	27	154
May	38	43	24	35	41	408	40	15	100
June	134	67	56	94	10	76	73	69	141
July	55	30	6	25	29	267	154	63	115
August	52	25	7	13	20	237	164	79	147
September	27	98	38	72	28	139	100	25	193
October	51	51	58	59	63	121	122	30	189
November	69	74	18	90	125	168	83	32	61
December	66	48	14	96	95	255	52	28	90

During this year
The N. wind was most prevalent in March, and least in September.
„ N.E. „ „ „ September, „ August.
„ E. „ „ „ April, „ July and August.
„ S.E. „ „ „ December, „ August.
„ S. „ „ „ November, „ June.
„ S.W. „ „ „ May, „ June.
„ W. „ „ „ Jan. andAug., „ April.
„ N.W. „ „ „ March, „ May.

Table VII.

1866. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	18	11	2	10	50	372	206	46	29
February	70	30	2	0	24	255	178	50	63
March	125	127	30	32	88	119	84	49	90
April	37	65	170	55	22	171	91	11	98
May	65	106	126	50	8	150	70	31	138
June	24	74	63	43	52	291	107	24	42
July	76	99	67	27	15	133	164	66	97
August	50	27	25	32	74	214	152	107	63
September	21	22	15	45	121	337	79	15	65
October	118	165	95	63	53	138	25	19	68
November	42	2	13	23	64	310	169	85	12
December	8	2	21	11	95	374	166	22	45

During this year
The N. wind was most prevalent in March, and least in December.
„ N.E. „ „ „ October, „ Nov. and Dec.
„ E. „ „ „ April, „ Jan. and Feb.
„ S.E. „ „ „ October, „ February.
„ S. „ „ „ September, „ May.
„ S.W. „ „ „ Jan. and Dec., „ March.
„ W. „ „ „ January, „ October.
„ N.W „ „ „ August, „ April.

TABLE VIII.

1867. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	100	38	56	55	83	226	76	97	13
February	20	36	63	25	76	292	128	12	20
March	88	276	134	24	37	111	31	31	12
April	36	25	22	27	62	288	194	48	18
May	73	125	138	87	115	142	24	20	20
June	209	89	35	33	36	187	61	69	1
July	50	73	72	69	68	254	85	60	13
August	32	29	53	54	77	444	38	17	0
September	75	63	39	38	91	296	73	37	8
October	76	37	22	69	119	295	75	46	5
November	160	96	16	32	33	175	70	87	51
December	121	77	21	12	62	146	131	103	71

During this year
The N. wind was most prevalent in June, and least in February.
„ N.E. „ „ „ March, „ April.
„ E. „ „ „ Mar. and May, „ November.
„ S.E. „ „ „ May, „ December.
„ S. „ „ „ October, „ November.
„ S.W. „ „ „ Sept.andOct.„ March.
„ W. „ „ „ April, „ May.
„ N.W. „ „ „ December, „ February.
In the month of Aug. there was not a calm hour, and one only in June.

TABLE IX.

1868. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	104	140	8	24	39	246	87	26	70
February	25	4	0	0	78	331	189	69	0
March	74	30	0	16	84	273	172	54	41
April	134	81	53	37	87	169	67	47	45
May	26	91	120	37	103	264	37	6	60
June	109	90	30	20	52	211	100	87	21
July	182	141	53	23	34	175	63	58	15
August	55	51	75	81	97	213	132	21	19
September	18	182	97	69	72	140	46	7	89
October	55	56	18	26	79	222	187	38	63
November	166	165	25	46	55	123	62	17	61
December	18	13	21	62	121	350	100	8	51

During this year
The N. wind was most prevalent in July, and least in September and Dec.
„ N.E. „ „ „ September, „ February.
„ E. „ „ „ May, „ Feb. and March.
„ S.E. „ „ „ August, „ February.
„ S. „ „ „ December, „ July.
„ S.W. „ „ „ December, „ November.
„ W. „ „ „ Feb.andOct. „ May.
„ N.W. „ „ „ June, „ May and September.
In the month of February there was not a calm hour.

TABLE X.

1869. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	3	6	37	170	196	246	37	0	49
February	32	30	9	4	51	347	156	43	0
March	179	267	37	50	31	61	46	69	4
April	64	139	103	37	60	237	61	16	3
May	54	202	138	65	46	170	52	16	1
June	132	155	25	20	32	190	79	60	27
July	57	108	55	58	30	267	89	39	41
August	71	136	59	50	21	173	114	72	48
September	22	31	25	54	74	328	166	4	16
October	95	21	25	97	56	181	130	118	21
November	72	21	12	14	32	260	195	105	9
December	133	122	57	8	77	199	65	71	12

During this year
The N. wind was most prevalent in March, and least in January.
„ N.E. „ „ „ March, „ January.
„ E. „ „ „ May, „ February.
„ S.E. „ „ „ January, „ February.
„ S. „ „ „ January, „ August.
„ S.W. „ „ „ February, „ March.
„ W. „ „ „ November, „ January.
„ N.W. „ „ „ October, „ January.
In the month of Feb. there was not a calm hour, and one only in May.

TABLE XI.

1870. Months.	Number of Hours of prevalence of each Wind, referred to different points of Azimuth.								Number of Calm or nearly Calm Hours.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January	54	125	36	81	101	223	68	12	44
February	34	192	52	62	135	111	43	36	7
March	130	262	28	19	48	115	52	87	3
April	61	34	84	51	44	201	118	84	43
May	63	105	63	66	31	298	46	44	28
June	96	97	21	25	14	193	177	93	4
July	60	115	67	42	35	217	141	61	6
August	164	185	44	23	16	118	81	105	8
September	19	109	122	56	46	218	95	27	28
October	48	70	62	25	55	264	156	64	0
November	77	67	43	60	67	238	121	28	19
December	138	210	69	65	23	106	73	29	31

During this year
The N. wind was most prevalent in August, and least in September.
„ N.E. „ „ „ March, „ April.
„ E. „ „ „ September, „ June.
„ S.E. „ „ „ January, „ March.
„ S. „ „ „ February, „ June.
„ S.W. „ „ „ May, „ December.
„ W. „ „ „ June, „ February.
„ N.W. „ „ „ August, „ January.
In the month of Oct. there was not a calm hour.

By taking the sums of the hours of prevalence of each wind from these Tables we obtain Table XII., which shows the total number of hours of prevalence of each wind for every year in the whole period.

TABLE XII. Showing the Number of Hours of prevalence of each Wind in the Years 1861–70.

Years.	Number of Hours the Mean direction of the Wind was—								Calm.	Resolved numbers to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	607	1019	680	420	481	2903	1403	623	624	1428	1399	2143	3166
1862.	642	1132	486	750	408	2829	1714	487	312	1451	1427	2198	3372
1863.	491	740	460	645	530	3329	1447	644	474	1183	1153	2517	3433
1864.	1040	1011	844	649	666	2578	756	412	828	1751	1674	2280	2251
1865.	974	740	451	641	578	2337	1127	539	1373	1613	1141	2068	2565
1866.	654	730	629	391	666	2864	1491	525	810	1282	1189	2294	3185
1867.	1040	964	671	525	859	2856	986	627	232	1835	1415	2550	2728
1868.	966	1044	500	441	901	2717	1242	438	535	1707	1242	2481	2819
1869.	914	1238	582	627	706	2659	1190	613	231	1839	1514	2349	2827
1870.	944	1571	691	575	615	2302	1171	670	221	2065	1764	2053	2657

The numbers in this Table differ very much from each other:—

The N. wind numbered	491 hours in	1862.
	1040 „	1864 and 1867.
The N.E. wind numbered	730 hours in	1866.
	1571 „	1870.
The E. wind numbered	451 hours in	1865.
	844 „	1864.
The S.E. wind numbered	391 hours in	1866.
	750 „	1862.
The S. wind numbered	408 hours in	1862.
	901 „	1868.
The S.W. wind numbered	2302 hours in	1870.
	3329 „	1863.
The W. wind numbered.........	756 hours in	1864.
	1714 „	1862.
The N.W. wind numbered......	412 hours in	1864.
	670 „	1870.
Calms, or nearly calms, numbered	221 hours in	1870.
	1373 „	1865.

By taking the means of the numbers in each column, we find that, from the ten years' observations, the average number of hours of wind in the year, with direction—

N.	was	827·2	hours, or about	$34\frac{1}{2}$	days.
N.E.	„	1018·9	„ „	$42\frac{1}{2}$	„
E.	„	599·4	„ „	25	„
S.E.	„	566·4	„ „	$23\frac{1}{2}$	„
S.	„	641·0	„ „	$26\frac{3}{4}$	„
S.W.	„	2737·4	„ „	114	„
W.	„	1252·7	„ „	52	„
N.W.	„	557·8	„ „	$23\frac{1}{4}$	„
Calm, or nearly calm,	„	564·0	„ „	$23\frac{1}{2}$	„

and taking the differences between these numbers and those in the corresponding columns gives us the first portion of Table XIII.

TABLE XIII. Showing the Number of Hours of departure of each Wind in every Year, 1861 to 1870, from the average.

Years.	Number of hours of departure in each direction of the Wind from the average.								Calm.	Resolved number of hours of departure from average.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	−220	0	+ 81	−146	−160	+166	+150	+ 65	+ 60	−187	+ 7	−150	+266
1862.	−185	+113	−113	+184	−233	+ 92	+461	− 71	−252	−164	+ 35	− 95	+472
1863.	−336	−279	−139	+ 79	−111	+592	+194	+ 86	− 90	−432	−239	+224	+533
1864.	+213	− 8	+245	+ 83	+ 25	−159	−497	−146	+264	+136	+282	− 13	−649
1865.	+147	−279	−148	+ 75	− 63	−400	−126	− 19	+809	− 2	−251	−225	−335
1866.	−173	−289	+ 30	−175	+ 25	+127	+238	− 33	+246	−333	−203	+ 1	+285
1867.	+213	− 55	+ 72	− 41	+218	+119	−267	+ 69	−332	+220	+ 23	+257	−172
1868.	+139	+ 25	− 99	−125	+260	− 20	− 11	−120	− 29	+ 92	−150	+188	− 81
1869.	+ 87	+219	− 17	+ 61	+ 65	− 78	− 63	+ 55	−333	+224	+122	+ 56	− 73
1870.	+117	+552	+ 92	+ 9	− 26	−435	− 82	+112	−343	+450	+372	−240	−243

The sign + denotes more than the average, and the sign − less than the average.

It will be observed in the Table that, in some years the departures from the averages have been great.

The following are the extreme departures in excess and defect:—

In 1864 and 1867	the	N.	was	213	hours in	excess.
1863	„	N.	„	336	„	defect.
1870	„	N.E.	„	552	„	excess.
1866	„	N.E.	„	289	„	defect.
1864	„	E.	„	245	„	excess.
1865	„	E.	„	148	„	defect.
1862	„	S.E.	„	184	„	excess.
1866	„	S.E.	„	175	„	defect.
1868	„	S.	„	260	„	excess.
1862	„	S.	„	233	„	defect.
1863	„	S.W.	„	592	„	excess.
1870	„	S.W.	„	435	„	defect.
1862	„	W.	„	461	„	excess.
1864	„	W.	„	497	„	defect.
1870	„	N.W.	„	112	„	excess.
1864	„	N.W.	„	146	„	defect.
1865 Calm		......	„	809	„	excess.
1870 Calm		......	„	343	„	defect.

It is also noticeable that, as was remarked in a previous reduction (1841–60), the signs, as a rule, occur in groups, in some cases for three or four consecutive years.

Reducing the numbers in the first part of Table XII. to the four cardinal points in each year, and taking their means, we find that for the ten years ending 1870,—

The average number from N., as found from N. and its compounds, is 1615·4 hours.

The average number from E., as found from E. and its compounds, is 1391·8 hours.

The average number from S., as found from S. and its compounds, is 2293·3 hours.

The average number from W., as found from W. and its compounds, is 2900·3 hours.

And these, with 564·0 calms, make up the entire year.

By taking the difference between these numbers and the corresponding numbers of each year, we shall determine the departure from the average of each wind in every year, over the mean of the ten years, and in this way the second part of Table XIII. has been determined. From these numbers we learn that—

In 1870 the N., as found from itself and compounds, was 450 hours in excess.

In 1863 the N., as found from itself and compounds, was 432 hours in defect.

Therefore in 1870 there were 882 hours of N. wind more than in 1863.

In 1870 the E., as found from itself and compounds, was 372 hours in excess.

In 1865 the E., as found from itself and compounds, was 251 hours in defect.

Therefore in 1870 there were 623 hours of E. wind more than in 1865.

In 1867 the S., as found from itself and compounds, was 257 hours in excess.

In 1870 the S., as found from itself and compounds, was 240 hours in defect.

Therefore in 1867 there were 497 hours of S. wind more than in 1870.

In 1863 the W., as found from itself and compounds, was 533 hours in excess.

In 1864 the W., as found from itself and compounds, was 649 hours in defect.

Therefore in 1863 there were 1182 hours of W. wind more than in 1864.

By combining the numbers in the second part of Table XII. with those found in my previous paper for the years 1841 to 1860, and laying the results down in diagrams, the periodic departure of the different directions of wind in groups of excess or defect above or below the average will be readily seen.

The inner circle of the four diagrams is drawn with a radius of 50 days, and the outer circle with a radius corresponding to that of the average continuance of each wind, reduced to the four cardinal points, as found from all the observations from the years 1841 to 1870. The several radii drawn to the irregular boundary-line show the number of days of duration in each year, projecting beyond the outer circle when the number was greater than the average, and falling within it when it was less than the average.

Diagrams showing the number of Days of continuance of each Wind, 1841 *to* 1870.

Diagram 1.

E.

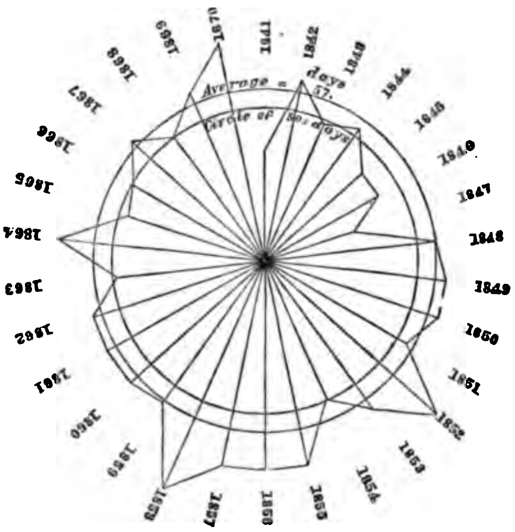
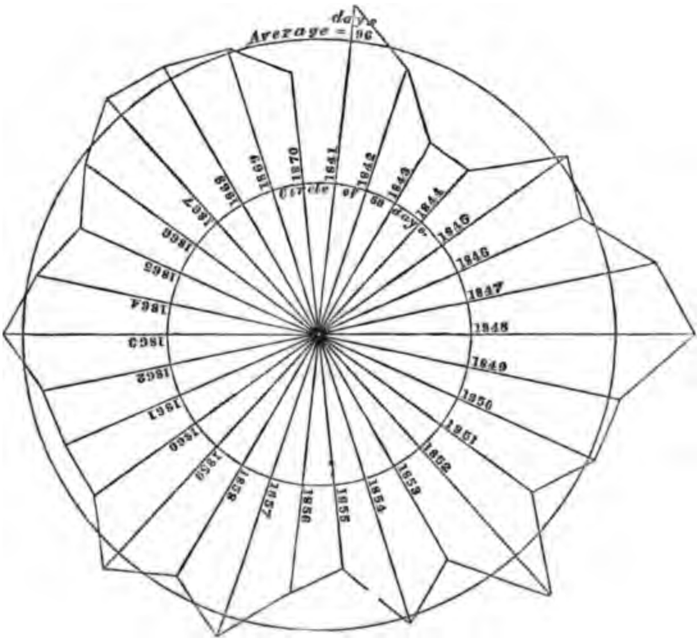


Diagram 3.

S.



Scale 63 days to 1 inch.

Diagram 2.

N.

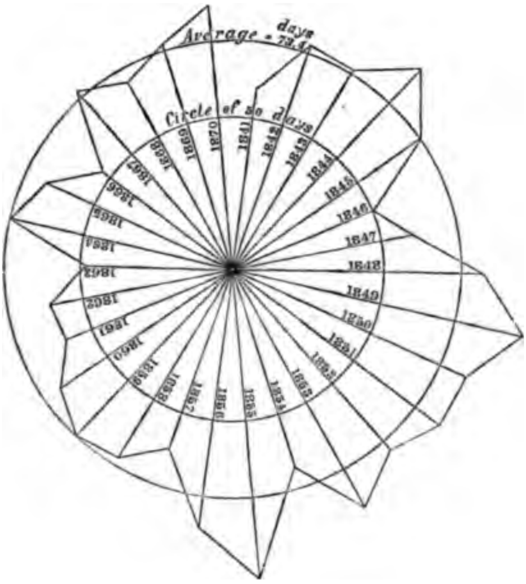
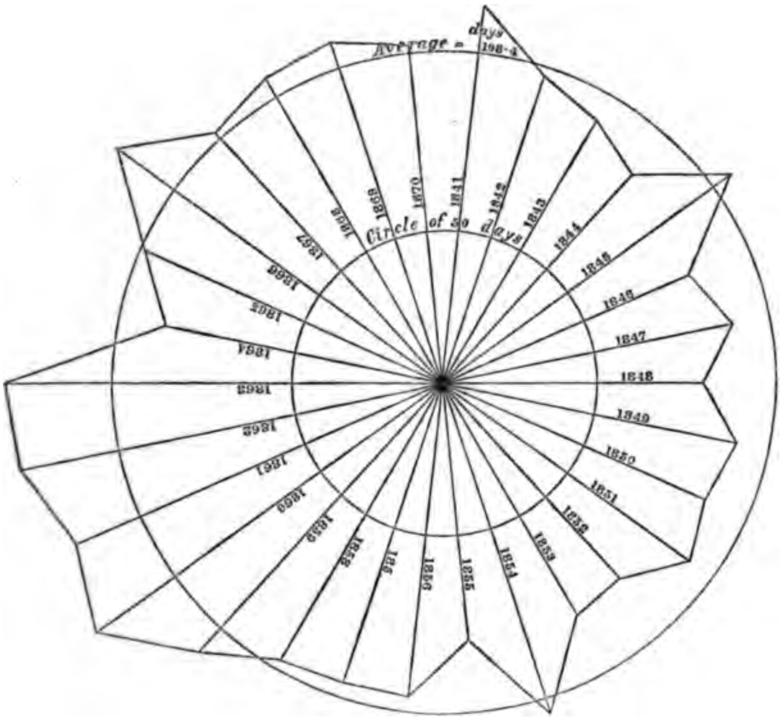


Diagram 4.

W.



Scale 63 days to 1 inch.

In Diagram 1, *that for the E. wind, as derived from itself and compounds*, the outer circle is but little removed from the 50 days' circle, the average continuance of the East wind being 57 days. By looking at the Diagram, it will be seen that in the year 1841 the point is well within the 50 days' circle; the direction of this wind was therefore much less than the average: in the years 1842, 1843, and 1844 the points fall a little outside the average circle; in the years 1845, 1846, and 1847 they all fall well within the 50 days' circle, the last-mentioned year having the shortest radius of any, implying that there was less East wind that year than in any other of the 30 years; and as the radii of these 3 years are less than in any other 3 years, the wind in these three consecutive years was less than in any other 3 years during the whole period. From the year 1848 to the present time it will be seen that the duration of the East wind has been but once just within the 50 days' circle, viz. in the year 1865, and that it was greatly over the average in the years 1852, 1858, and 1870; and that the duration of the East wind is longer generally, since the year 1847, than it was previously.

In Diagram 2, *that of the N. wind and its compounds*, the outer circle is further removed from the 50 days' circle than in Diagram 1, the average continuance of the N. wind and its compounds being 73½ days; and here is shown a deficiency of N. wind in the years 1841, 1845, 1846, 1847; generally an excess in the years 1848 to 1856; then mostly a deficiency till the year 1866, and an excess afterwards. By looking at the Diagram, it will be seen that on its right side, corresponding to the years in the first half of the series, the radii generally fall beyond the outer circle, whilst on the left side, corresponding to the years since 1856, they generally fall within, and only occasionally reach the average circle till after the year 1866. It would therefore appear that less wind has passed from the N. since the year 1856 than in those previous to that year.

In Diagram 3, *that for the S. wind*, the average circle departs still more from the inner circle of 50 days' duration, the average being 96 days. There was an excess in 1841; then, till 1845, the radii all fall well within the average circle, and more so than in any other group of 3 years within the period; this was followed by the 3 years 1847, 1848, and 1849, the radii of which fall more out of the circle than any other, implying more S. wind in those years than in any other 3 years; after this the wind was almost alternately year by year in excess or defect till 1857, since which time the departure from the average has not been great, the greatest being a deficiency of 11 days in the year 1870.

Diagram 4, *that for the W. wind*, shows the largest exterior circle of all, corresponding to 108¼ days nearly. It will be seen at a glance that from the beginning of the series to the year 1858, with the exception of the years 1841, 1845, and 1854, all the points fall within the average circle, whilst those from the year 1859 to the end of the series fall outside the circle, with the solitary exception of one year, viz. 1864, which falls within the circle, and particularly so in the years 1858 to 1863. This Diagram is

therefore very remarkable, as exhibiting a marked increase in the direction of this wind since the year 1857.

During the years 1841 to 1870 the excess or defect yearly of the whole number of revolutions of the vane of Osler's anemometer, of direct over retrograde, or of retrograde over direct, has been taken.

By direct motion is meant when the vane in its changing positions was moving in the order N., E., S., W., N. &c., or with the sun; by retrograde is meant in the order N., W., S., E., N., or backing against the sun.

In every year the whole angle through which the vane has turned in each direction has been determined, and the difference taken in terms of revolutions. In this way it was found—

In the year

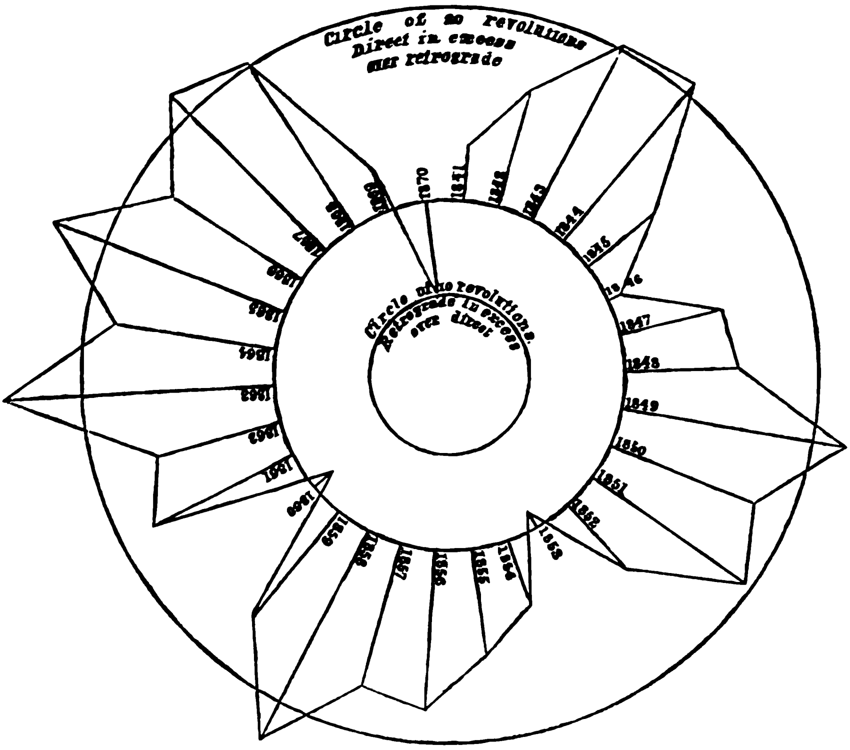
1841	the vane	turned through	= 5·4	revolutions	direct.
1842	„	„	=13·1	„	direct.
1843	„	„	=20·7	„	direct.
1844	„	„	=21·7	„	direct.
1845	„	„	= 8·9	„	direct.
1846	„	„	= 1·8	„	direct.
1847	„	„	=11·0	„	direct.
1848	„	„	=12·1	„	direct.
1849	„	„	=23·3	„	direct.
1850	„	„	=15·9	„	direct.
1851	„	„	=19·1	„	direct.
1852	„	„	= 8·8	„	direct.
1853	„	„	= 1·9	„	retrograde.
1854	„	„	= 6·8	„	direct.
1855	„	„	=10·8	„	direct.
1856	„	„	=16·1	„	direct.
1857	„	„	=14·7	„	direct.
1858	„	„	=24·1	„	direct.
1859	„	„	=14·0	„	direct.
1860	„	„	= 2·1	„	retrograde.
1861	„	„	=16·5	„	direct.
1862	„	„	=13·7	„	direct.
1863	„	„	=28·5	„	direct.
1864	„	„	=17·2	„	direct.
1865	„	„	=26·1	„	direct.
1866	„	„	=16·5	„	direct.
1867	„	„	=23·3	„	direct.
1868	„	„	=20·4	„	direct.
1869	„	„	= 4·9	„	direct.
1870	„	„	= 9·4	„	retrograde.

Till the year 1860 a period of 7 years was indicated by the small number of direct revolutions, or of retrograde revolutions, shown in 1841 (probably not the smallest), 1846, 1853, and 1860; but this hypothesis was not confirmed by the recurrence of a small number in 1867; the number

in fact was unusually large. By laying these numbers down in Diagram 5, in which the innermost circle shows the years when the retrograde movement was greater than the direct, and the outermost circle when the direct exceeded the retrograde, the amounts being measured in both cases from the intermediate or neutral circle by lines normal to itself, it will be seen at a glance that in the 30 years there have been four marked approaches towards the inner circle, viz. in 1846, 1853, 1860, and 1870, the last being the nearest approach; and the mean interval, if these be connected, would be 7¼ years. The points projecting beyond the outermost circle seem to follow no law.

Diagram showing the annual excess of direct over retrograde, and vice versâ, *of the whole number of Revolutions of the Vane of Osler's Anemometer, from the year* 1841 *to* 1870.

Diagram 5.



Scale 20 revolutions = 1 inch.

Having determined the average number of hours in each year of the duration of each wind, it is desirable to determine their distribution over the year; I have therefore collected all the results in each month together in all the years, and in this way Tables XIV. to XXV. have been formed:—

TABLES XIV. and XV. Showing the number of Hours of Wind during the months of January and February in each year.

Years.	JANUARY.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	12	64	35	18	47	267	20	15	266	51	76	190	161
1862.	36	68	39	131	73	232	129	36	0	88	138	255	263
1863.	17	92	13	58	72	340	84	55	13	91	88	271	281
1864.	42	87	106	221	47	207	23	11	0	91	260	261	132
1865.	62	75	20	17	67	248	167	37	51	118	66	200	309
1866.	18	11	2	10	50	372	206	46	29	47	12	241	415
1867.	100	38	56	55	83	226	76	97	13	167	102	224	238
1868.	104	140	8	24	39	246	87	26	70	187	90	174	223
1869.	3	6	37	170	196	246	37	0	49	6	125	404	160
1870.	54	125	36	81	101	223	68	12	44	123	139	253	185

During this month

The N. wind was most prevalent in 1867 and 1868, and least in 1869.
„ N.E. „ „ „ 1868, and least in 1869.
„ E. „ „ „ 1864, „ 1866.
„ S.E. „ „ „ 1864, „ 1866.
„ S. „ „ „ 1869, „ 1868.
„ S.W. „ „ „ 1866, „ 1864.
„ W. „ „ „ 1866, „ 1864.
„ N.W. „ „ „ 1867, „ 1869.

There was no instance of a calm hour in this month in the years 1862 and 1864.

Years.	FEBRUARY.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	25	87	14	55	79	262	47	42	61	89	85	238	199
1862.	60	84	95	133	50	78	116	24	32	114	203	156	167
1863.	29	13	54	58	2	314	104	52	46	61	90	188	287
1864.	182	158	56	22	20	202	36	20	0	271	146	132	147
1865.	82	91	49	23	48	200	65	47	67	151	106	160	188
1866.	70	30	2	0	24	255	178	50	63	110	17	151	331
1867.	20	36	63	25	76	292	128	12	20	44	93	235	280
1868.	25	4	0	0	78	331	189	69	0	61	2	244	389
1869.	32	30	9	4	51	347	156	43	0	69	26	226	351
1870.	34	192	52	62	135	111	43	36	7	148	179	222	116

During this month

The N. wind was most prevalent in 1864, and least in 1867.
„ N.E. „ „ „ 1870, „ 1868.
„ E. „ „ „ 1862, „ 1868.
„ S.E. „ „ „ 1862, „ 1866 and 1868.
„ S. „ „ „ 1870, „ 1863.
„ S.W. „ „ „ 1869, „ 1862.
„ W. „ „ „ 1868, „ 1864.
„ N.W. „ „ „ 1868, „ 1867.

There was no instance of a calm hour in this month in the years 1864, 1868, and 1869.

TABLES XVI. and XVII. Showing the number of Hours of Wind during the months of March and April in each year.

Years.	MARCH.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	36	2	13	0	7	249	265	128	44	101	14	132	453
1862.	43	160	80	63	29	278	48	19	24	133	191	200	196
1863.	65	72	22	61	49	155	111	109	100	155	88	158	243
1864.	71	122	128	54	20	195	64	41	49	152	216	145	182
1865.	248	59	61	55	15	82	72	87	65	321	118	84	156
1866.	125	127	30	32	88	119	84	49	90	213	110	164	167
1867.	88	276	134	24	37	111	31	31	12	242	284	104	102
1868.	74	30	0	16	84	273	172	54	41	116	23	228	336
1869.	179	267	37	50	31	61	46	69	4	347	195	86	112
1870.	130	262	28	19	48	115	52	87	3	305	168	115	153

During this month

The N. wind was most prevalent in 1865, and least in 1861.
„ N.E. „ „ „ 1867, „ 1861.
„ E. „ „ „ 1867, „ 1868.
„ S.E. „ „ „ 1862, „ 1861.
„ S. „ „ „ 1866, „ 1861.
„ S.W. „ „ „ 1862, „ 1869.
„ W. „ „ „ 1861, „ 1867.
„ N.W. „ „ „ 1861, „ 1862.

Years.	APRIL.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	85	139	211	8	0	34	48	66	129	187	285	21	98
1862.	12	174	6	64	10	285	125	35	9	116	125	185	285
1863.	49	86	41	37	16	214	105	120	52	152	103	141	272
1864.	66	69	106	42	40	115	31	37	214	119	162	119	106
1865.	90	79	100	62	37	136	35	27	154	144	170	136	116
1866.	37	65	170	55	22	171	91	11	98	75	230	135	182
1867.	36	25	22	27	62	288	194	48	18	72	48	220	362
1868.	134	81	53	37	87	169	67	47	45	198	112	190	175
1869.	64	139	103	37	60	237	61	16	3	141	191	197	188
1870.	61	34	84	51	44	201	118	84	43	120	126	170	261

During this month

The N. wind was most prevalent in 1868, and least in 1862.
„ N.E. „ „ „ 1862, „ 1867.
„ E. „ „ „ 1861, „ 1862.
„ S.E. „ „ „ 1862, „ 1861.
„ S. „ „ „ 1868, „ 1861.
„ S.W. „ „ „ 1867, „ 1861.
„ W. „ „ „ 1867, „ 1864.
„ N.W. „ „ „ 1863, „ 1866.

Tables XVIII. and XIX. Showing the number of Hours of Wind during the months of May and June in each year.

Years.	MAY.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	188	175	75	28	14	75	70	40	79	295	177	65	128
1862.	7	88	62	68	31	225	180	63	20	83	140	178	323
1863.	41	251	82	19	6	175	118	42	10	188	217	103	226
1864.	193	65	89	59	61	91	55	51	80	251	151	136	126
1865.	38	43	24	35	41	408	40	15	100	68	63	262	251
1866.	65	106	126	50	8	150	70	31	138	133	204	108	161
1867.	73	125	138	87	115	142	24	20	20	146	244	229	105
1868.	26	91	120	37	103	264	37	6	60	75	184	253	172
1869.	54	202	138	65	46	170	52	16	1	163	272	163	145
1870.	63	105	63	66	31	298	46	44	28	138	148	213	217

During this month

The N. wind was most prevalent in 1864, and least in 1862.
" N.E. " " " 1863, " 1865.
" E. " " " 1867 & '69, " 1865.
" S.E. " " " 1867, " 1863.
" S. " " " 1867, " 1863.
" S.W. " " " 1865, " 1861.
" W. " " " 1862, " 1867.
" N.W. " " " 1862, " 1868.

Years.	JUNE.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	99	138	117	36	17	202	81	30	0	183	204	136	197
1862.	70	35	3	14	15	249	210	103	21	139	27	147	386
1863.	41	41	30	67	32	263	195	40	11	81	84	197	347
1864.	51	23	33	6	78	307	163	46	13	85	48	234	340
1865.	134	67	56	94	10	76	73	69	141	202	137	95	145
1866.	24	74	63	43	52	291	107	24	42	73	121	219	265
1867.	209	89	35	33	36	187	61	69	1	288	96	146	189
1868.	109	90	30	20	52	211	100	87	21	197	85	168	249
1869.	132	155	25	20	32	190	79	60	27	240	112	137	204
1870.	96	97	21	25	14	193	177	93	4	191	82	123	320

During this month

The N. wind was most prevalent in 1867, and least in 1866.
" N.E. " " " 1869, " 1864.
" E. " " " 1861, " 1862.
" S.E. " " " 1865, " 1864.
" S. " " " 1864, " 1865.
" S.W. " " " 1864, " 1865.
" W. " " " 1862, " 1867.
" N.W. " " " 1862, " 1866.

There was no instance of a calm hour in June 1861, and but one in the year 1867.

TABLES XX. and XXI. Showing the number of Hours of Wind during the months of July and August in each year.

JULY.

Years.	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	8	2	16	26	46	440	157	49	0	33	30	279	402
1862.	43	13	7	23	14	319	282	43	0	71	25	185	463
1863.	109	120	42	79	44	126	97	56	71	197	141	147	188
1864.	89	91	48	13	12	295	74	43	79	156	100	166	243
1865.	55	30	6	25	29	267	154	63	115	101	33	175	320
1866.	76	99	67	27	15	133	164	66	97	158	131	95	263
1867.	50	73	72	69	68	254	85	60	13	117	143	229	242
1868.	182	141	53	23	34	175	63	58	15	281	136	133	179
1869.	57	108	55	58	30	267	89	39	41	130	138	193	242
1870.	60	115	67	42	35	217	141	61	6	148	145	165	280

During this month
The N. wind was most prevalent in 1868, and least in 1861.
„ N.E. „ „ „ 1868, „ 1861.
„ E. „ „ „ 1867, „ 1865.
„ S.E. „ „ „ 1863, „ 1864.
„ S. „ „ „ 1867, „ 1864.
„ S.W. „ „ „ 1861, „ 1863.
„ W. „ „ „ 1862, „ 1868.
„ N.W. „ „ „ 1866, „ 1869.
There was no instance of a calm hour in July 1861 and 1862.

AUGUST.

Years.	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	5	5	0	5	33	353	268	71	4	43	5	212	480
1862.	66	116	21	42	7	252	144	39	57	143	100	154	290
1863.	36	25	54	33	38	412	93	38	15	68	83	260	318
1864.	122	26	28	7	23	171	114	66	187	168	45	112	232
1865.	52	25	7	13	20	237	164	79	147	104	26	145	322
1866.	50	27	25	32	74	214	152	107	63	117	54	197	313
1867.	32	29	53	54	77	444	38	17	0	55	94	326	269
1868.	55	51	75	81	97	213	132	21	19	91	141	244	249
1869.	71	136	59	50	21	173	114	72	48	175	152	133	236
1870.	164	185	44	23	16	118	81	105	8	309	148	86	193

During this month
The N. wind was most prevalent in 1870, and least in 1861.
„ N.E. „ „ „ 1870, „ 1861.
„ E. „ „ „ 1868, „ 1861.
„ S.E. „ „ „ 1868, „ 1861.
„ S. „ „ „ 1868, „ 1862.
„ S.W. „ „ „ 1861, „ 1870.
„ W. „ „ „ 1861, „ 1867.
„ N.W. „ „ „ 1866, „ 1867.
There was no instance of a calm hour in August 1867.

Tables XXII. and XXIII. Showing the number of Hours of Wind during the months of September and October in each year.

Years.	SEPTEMBER.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	62	25	3	20	66	318	194	32	0	91	25	235	369
1862.	30	197	64	52	49	228	55	12	33	134	189	189	175
1863.	4	1	0	10	70	376	204	24	31	17	5	263	404
1864.	25	8	18	14	77	382	122	27	47	42	29	275	327
1865.	27	98	38	72	28	139	100	25	193	88	123	134	182
1866.	21	22	15	45	121	337	79	15	65	39	49	312	255
1867.	75	63	39	38	91	296	73	37	8	125	89	258	240
1868.	18	182	97	69	72	140	46	7	89	112	223	176	120
1869.	22	31	25	54	74	328	166	4	16	40	67	265	332
1870.	19	109	122	56	46	218	95	27	28	87	204	183	218

During this month
The N. wind was most prevalent in 1867, and least in 1863.
„ N.E. „ „ „ 1862, „ 1863.
„ E. „ „ „ 1870, „ 1863.
„ S.E. „ „ „ 1865, „ 1863.
„ S. „ „ „ 1866, „ 1865.
„ S.W. „ „ „ 1864, „ 1865.
„ W. „ „ „ 1863, „ 1868.
„ N.W. „ „ „ 1867, „ 1869.
There was no instance of a calm hour in September 1861.

Years.	OCTOBER.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	23	178	104	137	89	182	18	10	3	117	261	249	114
1862.	47	63	62	48	15	291	165	24	29	91	117	185	322
1863.	26	11	59	131	77	303	35	6	96	35	130	294	189
1864.	80	139	114	51	53	136	39	45	87	172	209	146	130
1865.	51	51	58	59	63	121	122	30	189	92	113	153	197
1866.	118	165	95	63	53	138	25	19	68	210	209	153	104
1867.	76	37	22	69	119	295	75	46	5	118	75	301	245
1868.	55	56	18	26	79	222	187	38	63	102	59	203	317
1869.	95	21	25	97	56	181	130	118	21	165	84	195	279
1870.	48	70	62	25	55	264	156	64	0	115	110	199	320

During this month
The N. wind was most prevalent in 1866, and least in 1861.
„ N.E. „ „ „ 1861, „ 1863.
„ E. „ „ „ 1864, „ 1868.
„ S.E. „ „ „ 1861, „ 1870.
„ S. „ „ „ 1867, „ 1862.
„ S.W. „ „ „ 1863, „ 1865.
„ W. „ „ „ 1868, „ 1861.
„ N.W. „ „ „ 1869, „ 1863.
There was no instance of a calm hour in October 1870.

TABLES XXIV. and XXV. Showing the number of Hours of Wind during the months of November and December in each year.

Years.	NOVEMBER.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	42	42	4	6	14	373	157	82	0	104	28	204	384
1862.	179	134	40	23	65	110	72	10	87	251	119	131	132
1863.	48	28	40	83	100	337	67	14	3	69	96	310	242
1864.	76	84	21	63	90	280	20	14	72	125	95	261	167
1865.	69	74	18	90	125	168	83	32	61	122	100	254	183
1866.	42	2	13	23	64	310	169	85	12	85	26	230	367
1867.	160	96	16	32	33	175	70	87	51	251	80	137	201
1868.	166	165	25	46	55	123	62	17	61	257	130	140	132
1869.	72	21	12	14	32	260	195	105	9	135	29	169	378
1870.	77	67	43	60	67	238	121	28	19	125	106	216	254

During this year
The N. wind was most prevalent in 1862, and least in 1861 and 1866.
" N.E. " " " 1868, " 1866.
" E. " " " 1870, " 1861.
" S.E. " " " 1865, " 1861.
" S. " " " 1865, " 1861.
" S.W. " " " 1861, " 1862.
" W. " " " 1869, " 1864.
" N.W. " " " 1869, " 1862.
There was no instance of a calm hour in November 1861.

Years.	DECEMBER.												
	Number of Hours the Mean direction of the Wind was								Hours Calm or nearly Calm.	Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N.	E.	S.	W.
1861.	22	162	88	81	69	148	78	58	38	132	210	183	181
1862.	49	0	7	89	50	282	188	79	0	88	52	235	369
1863.	26	0	23	9	24	314	234	88	26	70	28	185	435
1864.	43	139	97	97	145	197	15	11	0	118	215	292	119
1865.	66	48	14	96	95	255	52	28	90	104	86	271	193
1866.	8	2	21	11	95	374	166	22	45	20	28	287	364
1867.	121	77	21	12	62	146	131	103	71	211	65	141	256
1868.	18	13	21	62	121	350	100	8	51	29	58	327	279
1869.	133	122	57	8	77	199	65	71	12	229	122	181	200
1870.	138	210	69	65	23	106	73	29	31	257	207	108	141

During this month
The N. wind was most prevalent in 1870, and least in 1866.
" N.E. " " " 1870, " 1862 and 1863.
" E. " " " 1864, " 1862.
" S.E. " " " 1864, " 1869.
" S. " " " 1864, " 1870.
" S.W. " " " 1866, " 1870.
" W. " " " 1863, " 1864.
" N.W. " " " 1867, " 1868.
There was no instance of a calm hour in December 1862–1864.

By taking the means of the numbers in each of the twelve preceding Tables, the next Table is formed.

TABLE XXVI. Showing the number of Hours in each Month, as found from all the Observations, 1861 to 1870, referred to the eight points of the Azimuthal Circle and reduced to the four Cardinal Points.

Month.	Average number of Hours the Mean direction of the Wind was									Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	E.	S.	W.
January ...	44·8	70·6	35·2	78·5	77·5	260·7	89·7	33·5	53·5	96·9	109·6	247·3	236·7
February	55·9	72·5	39·4	38·2	56·3	239·2	106·2	39·5	29·6	111·8	94·7	195·2	245·5
March ...	105·9	137·7	53·3	37·4	40·8	163·8	94·5	67·4	43·2	208·5	140·7	141·6	210·0
April ...	63·4	89·1	89·6	42·0	37·8	185·0	87·5	49·1	76·5	132·4	155·2	151·4	204·5
May......	74·8	125·1	91·7	51·4	45·6	199·8	69·2	32·8	53·6	154·0	180·0	171·0	185·4
June......	96·5	80·9	41·3	35·8	33·8	216·9	124·6	62·1	28·1	167·9	99·6	160·2	264·2
July......	72·9	79·2	43·3	38·5	32·7	249·3	130·6	53·8	43·7	139·2	102·2	176·7	282·2
August...	65·3	62·5	36·6	34·0	40·6	258·7	130·0	61·5	54·8	127·3	84·8	186·9	290·2
Sept.......	30·3	73·6	42·1	43·0	69·4	276·2	113·4	21·0	51·0	77·5	100·3	229·0	262·2
Oct.	61·9	79·1	61·9	70·6	65·9	213·3	95·2	40·0	56·1	121·7	136·7	207·8	221·7
Nov.......	93·1	71·3	23·2	44·0	64·5	237·4	101.6	47·4	37·5	152·4	80·9	205·2	244·0
Decemb. .	62·4	77·3	41·8	53·0	76·1	237·1	110·2	49·7	36·4	125·8	107·1	221·0	253·7
Sums ...	827·2	1018·9	599·4	566·4	641·0	2737·4	1252·7	557·8	564·0	1615·4	1391·8	2293·3	2900·3

This Table shows the average duration of each wind in every month; from it we learn that, in the ten years 1861 to 1870:—

The N. wind was least prevalent in September.
„ N. wind was most prevalent in March.
„ N.E. wind was least prevalent in August.
„ N.E. wind was most prevalent in March.
„ E. wind was least prevalent in November.
„ E. wind was most prevalent in May.
„ S.E. wind was least prevalent in August.
„ S.E. wind was most prevalent in January.
„ S. wind was least prevalent in July.
„ S. wind was most prevalent in January.
„ S.W. wind was least prevalent in March.
„ S.W. wind was most prevalent in September.
„ W. wind was least prevalent in May.
„ W. wind was most prevalent in July and August.
„ N.W. wind was least prevalent in September.
„ N.W. wind was most prevalent in March.
Calm hours were least in number in June.
Calm hours were greatest in number in April.

In every month the S.W. wind has preponderated above any other direction. In September, this wind averages about two fifths of the month, in March and April about one fourth; and in the remaining months its duration is something more than one third.

The absolute and relative duration of the other winds can be seen by inspection of the Table, and from thence how the yearly sums have been distributed over the year.

The sums of the numbers in every column, showing the average yearly continuance of each wind, are as follows:—

		hours.
N.	wind, mean yearly continuance	827·2
N.E.	" " "	1018·9
E.	" " "	599·4
S.E.	" " "	566·4
S.	" " "	641·0
S.W.	" " "	2737·4
W.	" " "	1252·7
N.W.	" " "	557·8
Calm	" " "	564·0

These numbers are identical with the means of Table XII., and thus prove the correctness of the calculations up to this point.

By taking the difference between the numbers in Table XXVI., and the numbers for the different winds in every month in the several Tables XIV. to XXV., the next series of Tables are formed, showing the number of hours of departure of each wind above or below its average in every month.

It will be seen that, as was before noticed, the signs appear generally in groups of alternate + and —, thus indicating that series of years occur together with more than the average, and other series of years with less than the average duration of each wind.

Tables XXVII. and XXVIII. Showing the number of Hours of departure of each Wind during the months of January and February in each of the years 1861 to 1870, from its average, referred to Eight and to Four Points of the Compass.

The sign + denotes above, and the sign — below the average, in this and the following Tables.

JANUARY.

Years.	Number of Hours the Mean direction of the Wind differed from the average.									Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	E.	S.	W.
1861.	− 33	− 7	0	− 61	− 31	+ 6	− 70	− 19	+212	− 46	− 34	− 57	− 76
1862.	− 9	− 3	+ 4	+ 52	− 5	− 29	+ 39	+ 2	− 54	− 9	+ 28	+ 8	+ 26
1863.	− 28	+ 21	− 22	− 21	− 6	+ 79	− 6	+ 21	− 41	− 6	− 22	+ 24	+ 44
1864.	− 3	+ 16	+ 71	+142	− 31	− 54	− 67	− 23	− 54	− 6	+150	+ 14	−105
1865.	+ 17	+ 4	− 15	− 62	− 11	− 13	+ 77	+ 3	− 3	+ 21	− 44	− 47	+ 72
1866.	− 27	− 60	− 33	− 69	− 28	+111	+116	+ 12	− 25	− 50	− 98	− 6	+178
1867.	+ 55	− 33	+ 21	− 24	+ 5	− 35	− 14	+ 63	− 41	+ 70	− 8	− 23	+ 1
1868.	+ 59	+ 69	− 27	− 55	− 39	− 15	− 3	− 8	+ 16	+ 90	− 20	− 73	− 14
1869.	− 42	− 65	+ 2	+ 91	+118	− 15	− 53	− 34	− 5	− 91	+ 15	+157	− 77
1870.	+ 9	+ 54	+ 1	+ 2	+ 23	− 38	− 22	− 22	− 10	+ 26	+ 29	+ 6	− 52

FEBRUARY.

Years.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	E.	S.	W.
1861.	− 31	+ 14	− 25	− 17	+ 23	+ 23	− 59	+ 2	+ 31	− 23	− 10	+ 43	− 47
1862.	+ 4	+ 11	+ 56	+ 95	− 6	−161	+ 10	− 16	+ 2	+ 2	+108	− 39	− 79
1863.	− 27	− 60	+ 15	+ 20	− 54	+ 75	− 2	+ 12	+ 16	− 51	− 5	− 7	+ 41
1864.	+126	+ 85	+ 17	− 16	− 36	− 37	− 70	− 20	− 30	+159	+ 51	− 63	− 99
1865.	+ 26	+ 18	+ 10	− 15	− 8	− 39	− 41	+ 7	+ 37	+ 39	+ 11	− 36	− 57
1866.	+ 14	− 43	− 37	− 38	− 32	+ 16	+ 72	+ 10	+ 33	− 2	− 78	− 44	+ 85
1867.	− 36	− 37	+ 24	− 13	+ 20	+ 53	+ 22	− 28	− 10	− 68	− 2	+ 40	+ 34
1868.	− 31	− 69	− 39	− 38	+ 22	+ 92	+ 83	+ 29	− 30	− 51	− 93	+ 49	+133
1869.	− 24	− 43	− 30	− 34	− 5	+108	+ 50	+ 3	− 30	− 43	− 69	+ 31	+105
1870.	− 22	+119	+ 13	+ 24	+ 79	−128	− 63	− 4	− 23	+ 36	+ 84	+ 27	−130

TABLES XXIX. to XXXII. Showing the number of Hours of departure of each Wind during the months of March, April, May, and June in each of the years 1861 to 1870, from its average, referred to Eight and to Four Points of the Compass.

Years.	Number of Hours the Mean direction of the Wind differed from the average.									Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	E.	S.	W.
MARCH.													
1861.	− 70	−136	− 40	− 37	− 34	+ 85	+170	+ 61	+ 1	−107	−127	− 10	+243
1862.	− 63	+ 22	+ 27	+ 26	− 12	+114	− 47	− 48	− 19	− 75	+ 50	+ 58	− 14
1863.	− 41	− 66	− 31	+ 24	+ 8	− 9	+ 16	+ 42	+ 57	− 53	− 53	+ 16	+ 33
1864.	− 35	− 16	+ 75	+ 17	− 21	+ 31	− 31	− 26	+ 6	− 56	+ 75	+ 3	− 28
1865.	+142	− 79	+ 8	+ 18	− 26	− 82	− 23	+ 20	+ 22	+112	− 22	− 59	− 53
1866.	+ 19	− 11	− 23	− 5	+ 47	− 45	− 11	− 18	+ 47	+ 5	− 31	+ 22	− 43
1867.	− 18	+138	+ 81	− 13	− 4	− 53	− 64	− 36	− 31	+ 34	+143	− 38	−108
1868.	− 32	−108	− 53	− 21	+ 43	+109	+ 77	− 13	− 2	− 92	−118	+ 86	+126
1869.	+ 73	+129	− 16	+ 13	− 10	−103	− 49	+ 2	− 39	+139	+ 54	− 56	− 98
1870.	+ 24	+124	− 25	− 18	+ 7	− 49	− 43	+ 20	− 40	+ 97	+ 27	− 27	− 57
APRIL.													
1861.	+ 22	+ 50	+121	− 34	− 38	−151	− 40	+ 17	+ 52	+ 55	+130	−130	−107
1862.	− 51	+ 85	− 84	+ 22	− 28	+100	+ 37	− 14	− 68	− 16	− 30	+ 34	+ 80
1863.	− 14	− 3	− 49	− 5	− 22	+ 29	+ 17	+ 71	− 25	+ 20	− 52	− 10	+ 67
1864.	+ 3	− 20	+ 16	0	+ 2	− 70	− 57	− 12	+137	− 13	+ 6	− 32	− 99
1865.	+ 27	− 10	+ 10	+ 20	− 1	− 49	− 53	− 22	+ 77	+ 12	+ 15	− 15	− 89
1866.	− 26	− 24	+ 80	+ 13	− 16	− 14	+ 3	− 38	+ 21	− 57	+ 75	− 16	− 23
1867.	− 27	− 64	− 68	− 15	+ 24	+103	+106	− 1	− 59	− 60	−107	+ 69	+157
1868.	+ 71	− 8	− 37	− 5	+ 49	− 16	− 21	− 2	− 32	+ 66	− 43	+ 39	− 30
1869.	+ 1	+ 50	+ 13	− 5	+ 22	+ 52	− 27	− 33	− 74	+ 9	+ 36	+ 46	− 17
1870.	− 2	− 55	− 6	+ 9	+ 6	+ 16	+ 30	+ 35	− 34	− 12	− 29	+ 19	+ 56
MAY.													
1861.	+113	+ 50	− 17	− 23	− 32	−125	+ 1	+ 7	+ 25	+141	− 3	−106	− 57
1862.	− 68	− 37	− 30	+ 17	− 15	+ 25	+111	+ 30	− 34	− 71	− 40	+ 7	+138
1863.	− 34	+126	− 10	− 32	− 40	− 25	+ 49	+ 9	− 44	+ 34	+ 37	− 68	+ 41
1864.	+118	− 60	− 3	+ 8	+ 15	−109	− 14	+ 18	+ 26	+ 96	− 28	− 35	− 59
1865.	− 37	− 82	− 68	− 16	− 5	+208	− 29	− 18	+ 46	− 86	−118	+ 92	+ 66
1866.	− 10	− 19	+ 34	− 1	− 38	− 50	+ 1	− 2	+ 84	− 21	+ 24	− 63	− 24
1867.	− 2	0	+ 46	+ 36	+ 69	− 58	− 45	− 13	− 34	− 8	+ 64	+ 58	− 80
1868.	− 49	− 34	+ 28	− 14	+ 57	+ 64	− 32	− 27	+ 6	− 79	+ 4	+ 82	− 13
1869.	− 21	+ 77	+ 46	+ 14	0	− 30	− 17	− 17	− 53	+ 9	+ 92	− 8	− 40
1870.	− 12	− 20	− 29	+ 15	− 15	+ 98	− 23	+ 11	− 26	− 16	− 32	+ 42	+ 32
JUNE.													
1861.	+ 2	+ 57	+ 76	0	− 17	− 15	− 44	− 32	− 28	+ 15	+104	− 24	− 67
1862.	− 27	− 46	− 38	− 22	− 19	+ 32	+ 85	+ 41	− 7	− 29	− 73	− 13	+122
1863.	− 56	− 40	− 11	+ 31	− 2	+ 46	+ 70	− 22	− 17	− 87	− 16	+ 37	+ 83
1864.	− 46	− 58	− 8	− 30	+ 44	+ 90	+ 38	− 16	− 15	− 83	− 52	+ 74	+ 76
1865.	+ 37	− 14	+ 15	+ 58	− 24	−141	− 52	+ 7	+113	+ 34	+ 37	− 65	−119
1866.	− 73	− 7	+ 22	+ 7	+ 18	+ 74	− 18	− 38	+ 14	− 95	+ 21	+ 60	0
1867.	+112	+ 8	− 6	− 3	+ 2	− 30	− 64	+ 7	− 27	+120	− 4	− 14	− 75
1868.	+ 12	+ 9	− 11	+ 16	+ 18	− 6	− 25	+ 25	− 7	+ 29	− 15	+ 8	− 15
1869.	+ 35	+ 74	− 16	− 16	− 2	− 27	− 46	− 2	− 1	+ 72	+ 12	− 23	− 60
1870.	− 1	+ 16	− 20	− 11	− 20	− 24	+ 52	+ 29	− 24	+ 23	− 18	− 37	+ 56

TABLES XXXIII. to XXXVI. Showing the number of Hours of departure of each Wind during the months of July, August, September, and October in each of the years 1861 to 1870, from its average, referred to Eight and to Four Points of the Compass.

Years.	Number of Hours the Mean direction of the Wind differed from the average.									Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	E.	S.	W.
JULY.													
1861.	− 65	− 77	− 27	− 13	+ 13	+199	+ 26	− 5	− 44	−109	− 72	+102	+120
1862.	− 30	− 66	− 36	− 16	− 19	+ 70	+151	− 11	− 44	− 68	− 77	+ 9	+180
1863.	+ 36	+ 41	− 1	+ 40	+ 11	−123	− 34	+ 2	+ 27	+ 58	+ 39	− 30	− 94
1864.	+ 16	+ 12	+ 5	− 26	− 21	+ 46	− 63	− 11	+ 35	+ 18	− 2	− 11	− 40
1865.	− 18	− 49	− 37	− 14	− 4	+ 18	+ 23	+ 9	+ 71	− 38	− 69	− 1	+ 37
1866.	+ 3	+ 20	+ 24	− 12	− 18	−116	+ 33	+ 12	+ 53	+ 19	+ 29	− 82	− 19
1867.	− 23	− 6	+ 29	+ 30	+ 35	+ 5	− 46	+ 6	− 31	− 22	+ 41	+ 52	− 40
1868.	+109	+ 62	+ 10	− 16	+ 1	− 74	− 68	+ 4	− 29	+142	+ 34	− 44	−103
1869.	− 16	+ 29	+ 11	+ 19	− 3	+ 18	− 42	− 15	− 3	− 9	+ 34	+ 16	− 40
1870.	− 13	+ 36	+ 24	+ 3	+ 2	− 32	+ 10	+ 7	− 38	+ 9	+ 43	− 12	− 2
AUGUST.													
1861.	− 60	− 58	− 37	− 29	− 8	+ 94	+138	+ 9	− 51	− 84	− 80	+ 25	+190
1862.	+ 1	+ 53	− 16	+ 8	− 34	− 7	+ 14	− 23	+ 2	+ 16	+ 15	− 33	0
1863.	− 29	− 38	+ 17	− 1	− 3	+153	− 37	− 24	− 40	− 59	− 2	+ 73	+ 28
1864.	+ 57	− 37	− 9	− 27	− 18	− 88	− 16	+ 4	+132	+ 39	− 40	− 75	− 58
1865.	− 13	− 38	− 30	− 21	− 21	− 22	+ 34	+ 17	+ 92	− 23	− 59	− 42	+ 32
1866.	− 15	− 36	− 12	− 2	+ 33	− 45	+ 22	+ 45	+ 8	− 10	− 31	+ 10	+ 23
1867.	− 33	− 34	+ 16	+ 20	+ 36	+185	− 92	− 45	− 55	− 72	+ 9	+139	− 21
1868.	− 10	− 12	+ 38	+ 47	+ 56	− 46	+ 2	− 41	− 36	− 36	+ 56	+ 57	− 41
1869.	+ 6	+ 73	+ 22	+ 16	− 20	− 86	− 16	+ 10	− 7	+ 48	+ 67	− 54	− 54
1870.	+ 99	+122	+ 7	− 11	− 25	−141	− 49	+ 43	− 47	+182	+ 63	−101	− 97
SEPTEMBER.													
1861.	+ 32	− 49	− 39	− 23	− 3	+ 42	+ 81	+ 11	− 51	+ 13	− 75	+ 6	+107
1862.	0	+123	+ 22	+ 9	− 20	− 48	− 58	− 9	− 18	+ 56	+ 89	− 40	− 87
1863.	− 26	− 73	− 42	− 33	+ 1	+100	+ 91	+ 3	− 20	− 61	− 95	+ 34	+142
1864.	− 5	− 66	− 24	− 29	+ 8	+106	+ 9	+ 6	− 4	− 36	− 71	+ 46	+ 65
1865.	− 3	+ 24	− 4	+ 29	− 41	−137	− 13	+ 4	+142	+ 10	+ 23	− 95	− 80
1866.	− 9	− 52	− 27	+ 2	+ 52	+ 61	− 34	− 6	+ 14	− 39	− 51	+ 83	− 7
1867.	+ 45	− 11	− 3	− 5	+ 22	+ 20	− 40	+ 16	− 43	+ 47	− 11	+ 29	− 22
1868.	− 12	+108	+ 55	+ 26	+ 3	−136	− 57	− 14	+ 38	+ 34	+123	− 53	−142
1869.	− 8	− 43	− 17	+ 11	+ 5	+ 52	+ 53	− 17	− 35	− 38	− 33	+ 36	+ 70
1870.	− 11	+ 35	+ 80	+ 13	− 23	− 58	− 18	+ 6	− 23	+ 9	+104	− 46	− 44
OCTOBER.													
1861.	− 39	+ 99	+ 42	+ 66	+ 23	− 31	− 77	− 30	− 53	− 5	+124	+ 41	−108
1862.	− 15	− 16	0	− 23	− 51	+ 78	+ 70	− 16	− 27	− 31	− 20	− 23	+100
1863.	− 36	− 68	− 3	+ 60	+ 11	+ 90	− 60	− 34	+ 40	− 87	− 7	+ 86	− 33
1864.	+ 18	+ 60	+ 52	− 20	− 13	− 77	− 56	+ 5	+ 31	+ 50	+ 72	− 62	− 92
1865.	− 11	− 28	− 4	− 12	− 3	− 92	+ 27	− 10	+133	− 30	− 24	− 55	− 25
1866.	+ 56	+ 86	+ 33	− 8	− 13	− 75	− 70	− 21	+ 12	+ 88	+ 72	− 55	−118
1867.	+ 12	− 42	− 40	− 2	+ 53	+ 82	− 20	+ 6	− 51	− 4	− 62	+ 93	+ 23
1868.	− 7	− 23	− 44	− 45	+ 13	+ 9	+ 92	− 2	+ 7	− 20	− 78	− 5	+ 95
1869.	+ 32	− 58	− 37	+ 26	− 10	− 32	+ 35	+ 78	− 35	+ 43	− 53	− 13	+ 57
1870.	− 14	− 9	0	− 46	− 11	+ 51	+ 61	+ 24	− 56	− 7	− 27	− 9	+ 98

TABLES XXXVII. and XXXVIII. Showing the number of Hours of departure of each Wind during the months of November and December in each of the years 1861 to 1870, from its average, referred to Eight and to Four Points of the Compass.

Years.	Number of Hours the Mean direction of the Wind differed from the average.									Resolved Number to Cardinal Points.			
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	E.	S.	W.
NOVEMBER.													
1861.	− 51	− 29	− 19	− 38	− 51	+136	+ 55	+ 35	− 38	− 48	− 53	− 1	+140
1862.	+ 86	+ 63	+ 17	− 21	0	−137	− 30	− 37	+ 49	+ 99	+ 38	− 74	−112
1863.	− 45	− 43	+ 17	+ 39	+ 35	+100	− 35	− 33	− 35	− 83	+ 15	+105	− 2
1864.	− 17	+ 13	− 2	+ 19	+ 25	+ 43	− 82	− 33	+ 34	− 27	+ 14	+ 56	− 77
1865.	− 24	+ 3	− 5	+ 46	+ 60	− 69	− 19	− 15	+ 23	− 30	+ 19	+ 49	− 61
1866.	− 51	− 69	− 10	− 21	− 1	+ 73	+ 67	+ 38	− 26	− 67	− 55	+ 25	+123
1867.	+ 67	+ 25	− 7	− 12	− 32	− 62	− 32	+ 40	+ 13	+ 99	− 1	− 68	− 43
1868.	+ 73	+ 94	+ 2	+ 2	− 10	−114	− 40	− 30	+ 23	+105	+ 49	− 65	−112
1869.	− 21	− 50	− 11	− 30	− 33	+ 23	+ 93	+ 58	− 29	− 17	− 52	− 36	+132
1870.	− 16	− 4	+ 20	+ 16	+ 2	+ 1	+ 19	− 19	− 19	− 27	+ 25	+ 11	+ 10
DECEMBER.													
1861.	− 40	+ 85	+ 46	+ 28	− 7	− 89	− 32	+ 8	+ 2	+ 6	+103	− 38	− 73
1862.	− 13	− 77	− 35	+ 36	− 26	+ 45	+ 78	+ 29	− 36	− 38	− 55	+ 14	+115
1863.	− 36	− 77	− 19	− 44	− 52	+ 77	+124	+ 38	− 10	− 56	− 79	− 36	+181
1864.	− 19	+ 62	+ 55	+ 44	+ 69	− 40	− 95	− 39	− 36	− 8	+108	+ 71	−135
1865.	+ 4	− 29	− 28	+ 43	+ 19	+ 18	− 58	− 22	+ 54	− 22	− 21	+ 50	− 61
1866.	− 54	− 75	− 21	− 42	+ 19	+137	+ 56	− 28	+ 9	−106	− 79	+ 66	+110
1867.	+ 59	0	− 21	− 41	− 14	− 91	+ 21	+ 53	+ 35	+ 85	− 42	− 80	+ 2
1868.	− 44	− 64	− 21	+ 9	+ 45	+113	− 10	− 42	+ 15	− 97	− 49	+106	+ 25
1869.	+ 71	+ 45	+ 15	− 45	+ 1	− 38	− 45	+ 21	− 24	+103	+ 15	− 40	− 54
1870.	+ 76	+133	+ 27	+ 12	− 53	−131	− 37	− 21	− 5	+131	+100	−113	−113

By reducing the numbers in the first part of Table XXVI. to the four cardinal points, the second part of the same Table is formed; and taking the sums, we find that each wind, as formed from itself and compounds, is as follows:—

			hours.
The average duration of N.	....	is	1615·4
,, ,, ,, E.	....	is	1391·8
,, ,, ,, S.	....	is	2293·3
,, ,, ,, W.	....	is	2900·3

being identical with these found from the numbers in the second part of Table XII., and thus certifying their correctness in both cases.

By consulting the numbers in the last columns of Table XXVI., in every month, with those in the last columns of Tables XIV. to XXV., the mean duration of each wind, with its extreme durations, are readily found as follows:—

North and its compounds, reduced to North.

In *January* the average duration from the 10 years is 97 hours; in 1868 they continued 187 hours; but in 1869 only 6 hours.

In *February* the average duration is 112 hours; in 1864 the duration was 271 hours; in 1867 the continuance was 44 hours.

In *March* the average is 209 hours; the greatest continuance, viz. 347 hours, occurred in 1869, and the least (101 hours) in 1861.

In *April* the average is 132 hours; in 1868 it blew 198 hours; but only 72 hours in 1867.

In *May* the average is 154 hours; for 295 hours the air passed from this direction in 1861; in 1865 for 68 hours only.

In *June* the average is 168 hours; in 1867 it was prevalent for 288 hours; in 1866 for 73 hours.

In *July* the average is 139 hours; in 1868 it blew for 281 hours; in 1861 for 33 hours only.

In *August* the average duration is 127 hours; it prevailed for 309 hours in 1870, in 1861 for 43 hours.

In *September* the average is 77½ hours; it blew for 134 hours from this direction in 1862, while in 1863 only 17 hours were registered.

In *October* the average is 122 hours; it prevailed 210 hours in 1866, and 35 hours only in 1863.

In *November* the average is 152 hours; the duration exceeded 250 hours in 1862, 1867, and 1868, but was only 69 hours in 1863.

In *December* the average duration is 126 hours. The maximum duration for this month in the period 1861 to 1870 was 257 hours, and occurred in 1870, the minimum duration being but 20 hours in 1866.

East and its compounds, reduced to East.

In *January* the average duration of the E. wind from the ten years is 110 hours; in 1864 it was prevalent for 260 hours, but in 1866 for 12 hours only.

In *February* the average duration is 95 hours; in 1862 it was 203 hours; but in 1868 and 1866 scarcely any air passed from this quarter, the continuance being only 2 and 17 hours respectively.

In *March* the average duration is 141 hours; it prevailed for 284 hours in 1867, and but 14 hours in 1861.

In *April* the average is 155 hours; in the year 1861 it blew 285 hours; in 1867 but 48 hours.

In *May* the average duration is 180 hours; in 1869 the duration was 272 hours; in 1865 but 63 hours.

In *June* the average is 100 hours; in one year only (1861) the duration exceeded 200 hours, while in 1862 (the least duration) 27 hours occurred.

In *July* the duration is 102 hours; in the year 1870 it blew for 145 hours; in 1862 for 25 hours only.

In *August* the average duration is 85 hours; in 1869 it was prevalent for 152 hours; while in 1861 the duration was but 5 hours.

In *September* the average is 100 hours; in 1868 it was prevalent for 223 hours; in 1863 for 5 hours only.

In *October* the average is 137 hours; in 1861 it blew for 261 hours; in 1868 for 59 hours.

In *November* the average is 81 hours; the maximum duration in the period 1861 to 1870 was 130 hours, which occurred in 1868; in 1861, 1866, and 1869 the durations were 28, 26, and 29 hours respectively.

In *December* the average duration is 107 hours; in 1864 it was 215 hours; in 1863 and 1866, 28 hours only.

South and its compounds, reduced to South.

In *January* the average duration of the S. wind from the ten years is 247 hours; in 1869 it blew for 404 hours; but in 1868 for 174 hours only.

In *February* the average duration is 195 hours; the greatest duration, 244 hours, occurred in 1868, the least, 132 hours, in 1864.

In *March* the average duration is 142 hours; it was prevalent for 228 hours in 1868, and for 84 hours in 1865.

In *April* the average duration is 151 hours; it blew from this direction 220 hours in 1867, but for 21 hours only in 1861.

In *May* the average duration is 171 hours; it was prevalent for 262 hours in 1865, and for 65 hours in 1861.

In *June* the average duration is 160 hours; the prevalence in 1864 was 234 hours, in 1865, 95 hours.

In *July* the average duration is 177 hours; in 1861 was 279 hours, and in 1866, 95 hours.

In *August* the average duration is 187 hours; in 1867 it blew for 326 hours from this quarter, in 1870, 86 hours.

In *September* the average duration is 229 hours; in 1866 its continuance was 312 hours, in 1865, 134 hours.

In *October* the average duration is 208 hours; in 1867 it was 301 hours, in 1864 it was 146 hours.

In *November* the average duration is 205 hours; the longest continuance was 310 hours in 1863, and the shortest 131 hours in 1862.

In *December* the average duration is 221 hours; in 1868 it was 327 hours, and in 1870 it was 108 hours.

West and its compounds, reduced to West.

In *January* the average duration of the W. wind from the ten years is

237 hours; in 1866 it blew for 415 hours from this direction, in 1 132 hours.

In *February* the average duration is 246 hours; in 1868 it w hours; in 1870 it was 116 hours.

In *March* the average duration is 210 hours; in 1861 it was 453 in 1867 it was 102 hours.

In *April* the duration is 205 hours; its prevalence in 1867 w hours, in 1861 it was 98 hours.

In *May* the average duration is 185 hours; it prevailed 323 h 1862, and 105 hours in 1867.

In *June* the average duration is 264 hours; it was 386 hours i and 145 hours in 1865.

In *July* the average duration is 282 hours; in 1862 it was 463 in 1868 it was 179 hours.

In *August* the average duration is 290 hours; it blew for 480 from this direction in 1861, and for 193 hours in 1870.

In *September* the average duration is 262 hours; it was 404 h 1863; in 1868, 120 hours only.

In *October* the average duration is 222 hours; the greatest numb 322 hours in 1862; the least was 104 hours in 1866.

In *November* the average duration is 244 hours; it blew fro quarter for 384 hours in 1861, and for 132 hours in 1862 and 1868.

In *December* the average duration is 254 hours; in 1863 it prevail 435 hours, but in 1864 for 119 hours only.

In the present communication I have adopted the mode of repres graphically the results of the Tables which I made use of in my paper on the subject, and which is now in general use; it is to be n however, that care must be taken not to deduce inferences fro Diagrams which were not intended. The absolute lengths of th corresponding to the different years are the only quantities the Di are intended to show; and although the extremities of these ra joined, to render more evident to the eye the departures from the av I do not attach importance to the exact shape of the indentatio protuberances in this broken line. Strictly speaking, it would be proper to take points equidistant from one another along an axis different years, and erect ordinates at these points to represent the here denoted by radii; and this method would have the advantage it were desired to include more years, there would be no overlappi the ordinates. Although it thus appears that the circular mode of sentation is only properly appropriate for periodical phenomena, it to me now, as it did formerly, that the physical facts are in this way dered more obvious to the eye; and this is, in fact, all that is contem

in giving a Diagram. For deductions requiring accuracy the Table itself should be consulted. It should also be remarked that when the wind has blown for a certain number of hours from a point of the compass midway between two cardinal points, this number of hours has been equally divided between the two cardinal points; thus, in Table XII. and subsequent Tables, a wind of 4 hours' duration from the south-west has been regarded as a south wind for 2 hours and a west wind for 2 hours. It might seem more proper to resolve durations, like forces, velocities, &c., according to the parallelogram law, and regard the 4 hours' south-west wind as equivalent to a south and west wind, each of $2\sqrt{2}$ hours' duration; and this would be theoretically a better mode of resolution. On consideration, however, it does not appear that the duration of the wind admits, when resolved, of quite so accurate an interpretation as resolved velocity and force. If the wind move from the south-west with velocity 4, at any instant, this is exactly equivalent to a south and west wind, each moving with velocity $2\sqrt{2}$. In the case of time, however, the interpretation is not quite so clear, unless we suppose the duration proportional to the velocity or pressure; it therefore seemed sufficient to merely halve the amount. I may mention, in conclusion, that I have it in contemplation to discuss the pressure and velocity of the wind, resolving throughout according to the parallelogram law; this investigation cannot fail to yield results of interest and importance.

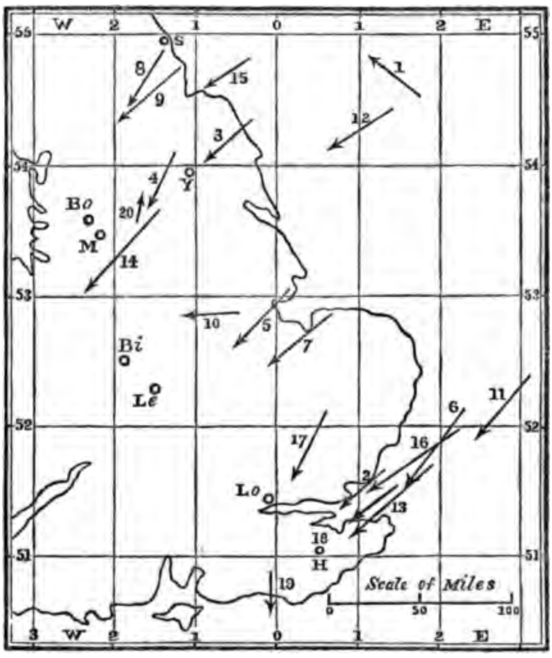
II. *Observations of the August Meteors in* 1871.

By Professor ALEXANDER S. HERSCHEL, F.R.A.S.

A SOMEWHAT unusually bright shower of the August meteors was visible in England on the nights of the 10th and 11th of August last, of which, although clouds concealed the sky at most of the stations in the north, a generally favourable view was yet obtained, and the apparent courses of about 350 meteors were mapped by observers in different parts of England, whose watchfulness on those nights, and on the 9th of August, between the hours of 10 P.M. and midnight, was specially requested by the Luminous-Meteor Committee of the British Association, with the view of determining as exactly as possible the position and changes of position of the radiant-point during the progress of the shower. Among the long list of shooting-stars, of which the times and the other principal particulars, including their apparent paths by the stars, were exactly registered, and are contained in copious descriptions of the star-shower communicated by observers at several widely distant stations, for general comparison together, to the Committee, many of the meteors described are satisfactorily identified as having been seen and recorded simultaneously at more than one of the corresponding stations.

In the accompanying list of the accordant observations, the real heights above the earth of the points of the meteors' first appearance and dis-

appearance, and the lengths and velocities of their real paths, as far as they could be ascertained from the observations, are included in separate columns of the Table, following the original descriptions of the meteors' apparent course and appearance at the different stations. The last five columns of the Table contain the true radiant-points and the localities over which the meteors moved, as they are directly derived from the observations. The positions of these points and the projections of the meteors' courses, together with the positions of the observers' stations, are shown on the accompanying outline map of England*. Collecting together the horizontal distances from the observers of the points of dis-



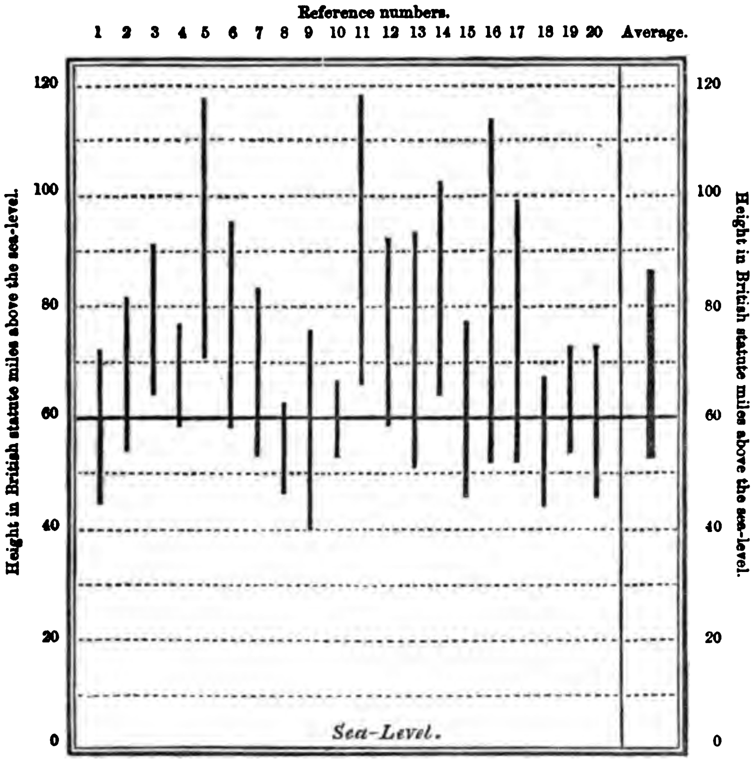
appearance of eighteen (omitting Nos. 5 and 20) of the meteors doubly observed during the simultaneous watch, it appears that among these meteors (only in a few cases slightly brighter than the fixed stars) nearly three fifths (21, or 57 per cent.) of the observed disappearances took place at horizontal distances between 40 and 80 miles from the observers, scarcely one fifth (7 cases, or 19 per cent.) took place at horizontal distances of less than 40 miles, and less than the remaining fifth (6 cases, or 16 per cent.) at distances of between 80 and 120 miles. Three instances only occur (8 per cent.) in which the disappearance of a meteor was noted at a greater horizontal distance than 120 miles from the observer's point of view. From this result of the observations it may be inferred that within a circular horizon of 80 miles in radius about four

* References to the Stations:—Bi, Birmingham; Bo, Bolton, Lancashire; H, Hawkhurst, Kent; Le, Leamington, Warwickshire; Lo, London; M, Manchester; S, Sunderland. Durham; Y, York.

fifths, and within a horizon of 120 miles in radius nine tenths of all the meteors capable of being exactly recorded are visible to an observer at its centre. Among the most distant meteors, the first in this list, doubly observed at Birmingham and York, was yet so well recorded and so similarly described by the observers, Mr. Wood and Mr. Clark, at the two places, that its real course and its horizontal distances at disappearance, of about 120 miles from York and about 220 miles from Birmingham, were capable of being very exactly and satisfactorily well ascertained.

In calculating the meteors Nos. 5, 9, 20, and in some less important cases, where the descriptions of the apparent paths are wanting in perfect completeness or agreement, a radiant-point was adopted agreeing well

Heights of Twenty Shooting-Stars doubly recorded by the Observers at British-Association Stations in England on the Nights of the 9th to 12th of August, 1871.



with the other appearances of the meteor's flight; and small departures from the original observations were required to adapt them to approximate calculation. But the elevations, and the other particulars of the meteor's real course, have in each case been obtained with, generally, very small deviations from the indicated paths. The average heights of appearance and disappearance, 86 and 52·5 miles, agree very closely with the similarly

computed heights of twenty shooting-stars of the August star-shower in the year 1863, 82 and 58 miles. The average length of path, 46 miles, is also very nearly the same as that, 53 miles, computed in the latter year. But the average velocity of nine Perseïds contained in this list, 51 miles per second, considerably exceeds the average velocity of 34·3 miles per second observed in the year 1863: the difficulty of estimating exactly the exceedingly small duration of their rapid flights may be accepted, with very little hesitation, as affording, doubtless, the true as well as a sufficiently obvious explanation of this apparent disagreement. The accompanying diagram (p. 35) of meteor-heights presents in a single view the real elevations obtained by the comparison of these observations, together with the average heights of first ignition and extinction or final dispersion of the August meteors, in the present year, by the heat and concussion of the air, violently compressed before them in their sudden collision with the earth's atmosphere. The following abstract list of observations contains a comparison of the relative frequency of the meteors seen on the principal nights of the shower, and the number of meteor-tracks recorded by observers at the British-Association stations, according to the more or less favourable views of the progress of the shower which they obtained on the nights of the systematic watch. A very complete series of observations of the numbers and appearance of the meteors of the shower on the night of the 10th of August was made by Captain J. Maclear, R.N., and Professor T. J. Main, of the Royal Naval College, who, observing together at Portsmouth from the Observatory of the College, counted the following numbers of meteors in the successive half-hours ending at:—

1871, August 10 ...	$10^h 30^m$.	11^h.	$11^h 30^m$.	12^h.	$12^h 30^m$.	13^h.	$13^h 30^m$.	14^h.	Total.
No. of meteors counted.........	5	10	10	15	29	27	14	23	133

both observers watching together during the hour between midnight and 1 o'clock. As will be seen by the following list, the half-hourly numbers which they recorded agree very nearly with those noted by other observers of the star-shower on the same night.

Place of Observation.	August 9th. Hour. From	August 9th. Hour. To	August 9th. No. of Meteors.	August 9th. State of Sky &c.	August 10th. Hour. From	August 10th. Hour. To	August 10th. No. of Meteors.	August 10th. State of Sky &c.	August 11th. Hour. From	August 11th. Hour. To	August 11th. No. of Meteors.	August 11th. State of Sky &c.	Observers.
	h m	h m			h m	h m			h m	h m			
York	......	......	...	....	9 45	12 0	120	Haze and some clouds. Three observers.	10 0	12 0	47	Hazy. Two observers.	J. E. Clark, A. K. Brown, T. H. Waller.
Birmingham	10 45 (hourly No.)	12 0	12	Clear. One observer.	10 30 (hourly No.)	12 0	24	Clear. One observer.	10 30 (hourly No.)	12 0	16	Clear. One observer.	W. H. Wood.
London	......	......	...	....	9 30	11 0	36	Clear. One observer.	......	......	...	....	T. Crumplen.
					11 0	12 0	46						
Thruxton, Norfolk	......	......	...	....	10 0	11 0	39	Clear. One observer.	......	......	...	....	Henry Wright ('The Times,' August 14th).
					11 0	11 30	22						
					11 30	12 0	7						
Bristol	11 30	12 0	7	Clear. One observer.	10 0	11 0	17	Clear. One observer.	10 35	10 50	18	Clear. One observer.	William F. Denning.
	12 0	13 0	27		11 0	12 0	27		11 0	12 0	29		
	13 0	14 0	8		12 0	12 30	27		12 0	12 30	31		
	14 0	15 0	21						12 30	13 0	23		
									13 0	13 30	25		
Upton Helions, Devon	10 15	10 40	1	One observer.	9 44	10 34	11	Clear. One observer.	10 36	11 36	20	Clear. One observer.	S. J. Johnson (communicated by W. F. Denning).
	11 13	11 52	7		11 4	12 12	42						
Numbers of Meteors Mapped.													
Edinburgh	10 25	11 17	3	Cloudy	......	......	...	....	......	......	...	....	T. W. Backhouse.
Sunderland	......	......	...	....	......	......	...	....	10 21	11 19	3	Very foggy......	
York	10 35	11 18	3	Cloud and haze.	9 44	11 56	53	Haze and some clouds.	10 7	11 59	22	Hazy	J. E. Clark, A. K. Brown, T. H. Waller, S. P. Thomson.
Manchester	......	......	...	....	10 56	12 44	27	Clear.	......	......	...	....	R. P. Greg.
Bolton, Lancashire	......	......	...	....	......	......	...	....	10 20	11 1	9	Clear	
Birmingham	10 46	12 0	12	Clear.	10 27	12 3	23	Clear.	10 35	12 3	18	Clear	W. H. Wood.
London	8 50	12 27	13	Clear.	9 46	12 5	21	Clear.	9 52	11 59	22	Clear	T. Crumplen.
Hawkhurst, Kent	10 40	12 53	17	Clear.	10 4	12 0	26	Clear.	9 45	12 58	34	Clear	J. Herschel.
	9 8	9 46	5	Clear.	9 36	12 3	23	Clear.	10 27	12 17	21	Clear	F. Herschel.
Total Numbers of Meteors mapped	8 50	12 53	53	....	9 36	12 44	173	....	9 45	12 58	129	....	Total number of Meteors Mapped in $10^h 24^m$ ... 355

III. *Electric Cumulus.* By S. Barber, F.M.S.

Thunderstorms have been more than usually numerous during the past three months in this neighbourhood (Hadleigh, Suffolk); and there has been no instance, that I am aware of, which was not heralded by the appearance of the cloud which I have called "electric cumulus." It has clearly distinguishing marks; and since attention does not seem to have been much directed to its connexion with electrical discharges, I offer the following remarks, premising that the cloud seems to have a similar appearance on the west and east coasts and in the midland district. It may be easily distinguished at a great* distance when just rising above the horizon: then it often has a pale yellow appearance.

Though liable to assume fantastic and *craggy* forms immediately before the disturbance, yet there seems to be a curious tendency to a constant† magnitude in the vertical angle, probably about 60° is the most ordinary. But the really distinctive trait is found in the markings of the surface. There is a very *specky* appearance, and many small curved lines are seen: on a nearer view these turn out to be the edges &c. of nodular projections, which indicate an internal fermenting or protruding force.

Electric Cumulus.

Fig. 1.

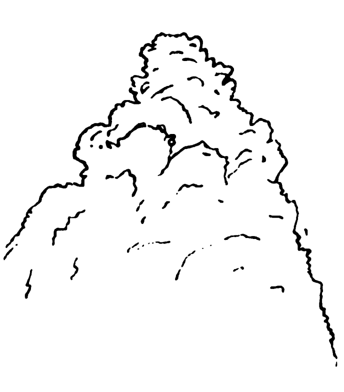


Fig. 2.

This cloud is often seen isolated, and seems possessed of a repulsive power, the edge sharply defined and showing little tendency to coalesce with those of neighbouring clouds. The outline of this edge is well worthy of notice; the prominences are small but very numerous, and have a tendency to a spherical form, reminding one of a mass of bubbles.

The axis of the cone, which represents the normal shape of the "electric cumulus," is often inclined to the horizon, as in fig. 2.

* Some notes on this point were published by me in the 'Student' for April 1870, last page.

† The angle is, of course, that of a vertical section through the apex of a cone; and the cone is often a very regular one.

The great thunderstorm of June 19th and 20th was preceded by many of these clouds. The movements of the storm seem to have been rather peculiar. Thus it was felt in parts of Suffolk and also in Cheshire on Monday 19th, and not till the 20th in other parts of the first-mentioned county.

IV. *Notes upon the Aurora Borealis of* 1871, *November* 10.

By W. C. Nash.

h m

At 9 10 there was a black mass across Ursa Major, and faint diffused white light along north.

9 15. Sudden appearance of red light between Cygnus and Lyra.

9 18. Great mass of ruddy light across lower part of Cygnus, and across Lyra and Draco; the principal brightness is near α Lyræ; bright bluish-white streamers cross the mass of red light. Below the mass of red light there is intense bluish-white light like day-dawn. The black patch still remains across Ursa Major. The red light was somewhat intermittent; it faded at $9^h\ 19^m$, and again became brighter after $9^h\ 20^m$.

9 25. Fine mass of whitish streamers reaching almost to zenith (to α Cephei). Black patch now broken up into detached fragments, and there is fine white light along north, with red mass as before in north-west.

9 28. Short and sharply defined streamers to left of η Ursæ Majoris; eastward from that constellation there are small broken dark fragments and diffused light.

9 31. The dark fragments have entirely disappeared, and there is now only a little diffused light in north.

9 31 to $9^h\ 40^m$. Diffused light.

9 41. Bright reddish light between α Lyræ and β and γ Draconis; below there is bluish-white light with streamers shooting up across the red light.

9 44. Faint white streamer close to the left of β Draconis, and another passing by right of α Lyræ; red light above α Lyræ.

9 46. Bright white streamers shooting up below α Lyræ and towards Cygnus; as these increased in altitude, their upper extremities became red and intense.

9 48. White streamer 5° to east of β Ursæ Majoris pointing up to and almost reaching α Persei; short streamers in Ursa Major and to left, whilst there is a red mass with streamers still existing between α Lyræ and δ Cygni.

9 50. Diffused light only: no definition: no red light.

h m

At 9 51. Many short streamers pointing to θ Draconis, and extending 10° to right and left.

9 53. Diffused.

9 56. Long low flat greenish-white arch passing between η and ζ Ursæ Majoris; the sky appears very dark by contrast below the arch; above the principal mass of light there are disconnected white streamers passing transversely between α Ursæ Majoris and Polaris.

10 0 to 10^h 18^m. The arch remained unchanged.

10 26. Several black patches between α Lyræ and Ursa Major; line of light below.

10 35 the black patches had disappeared.

10 40 to 11^h 15^m. Nothing worthy of note.

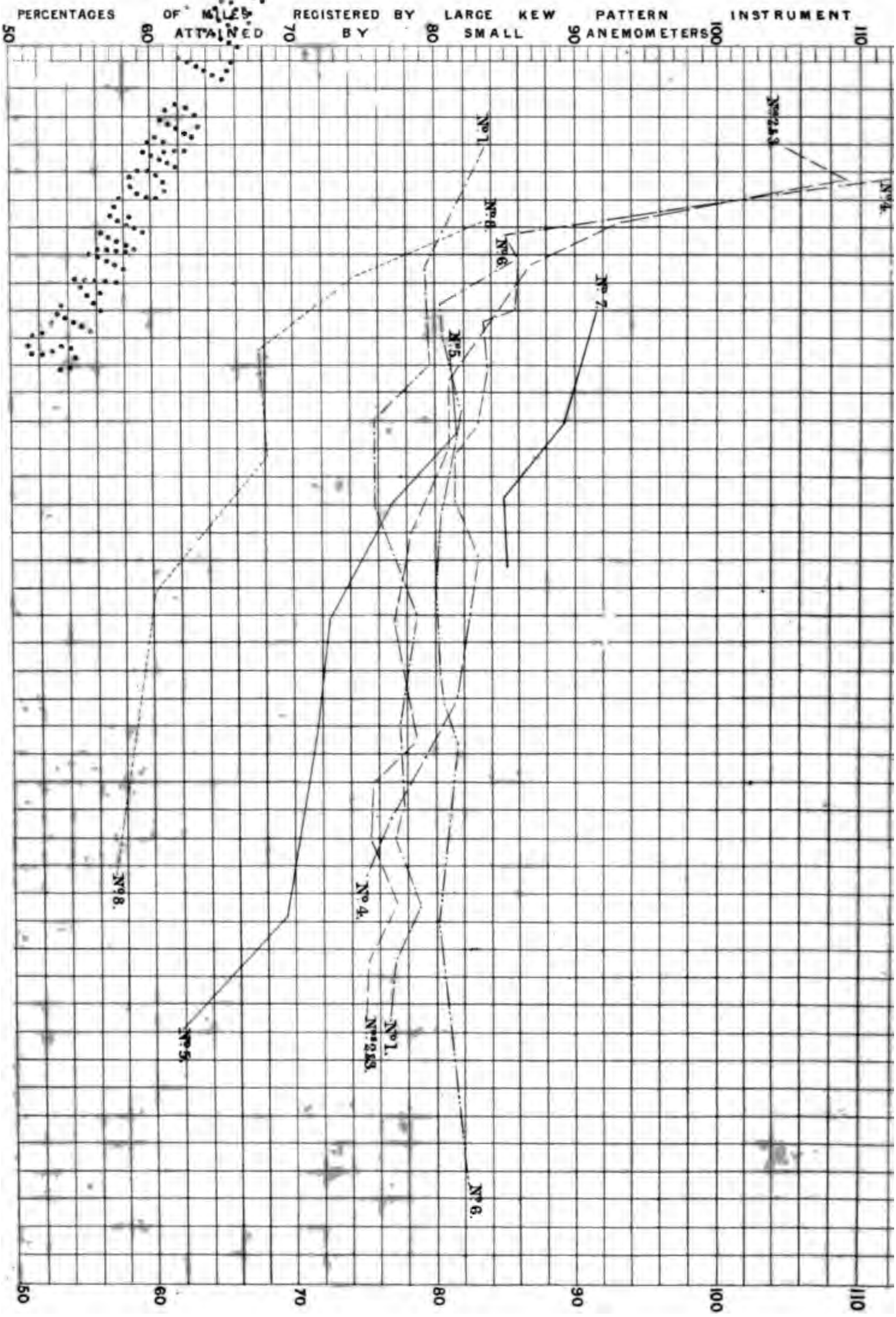
11 15. Dense cloud-like fragments along north, bright bluish-white light around.

11 19. Fine bright streamer from behind cloud up to θ Draconis.

11 26. Ruddy appearance in Cygnus; clouds as before; bluish-white light in north.

11 40. Clouds and bluish-white light still.

11 45. Observations discontinued.



Nº 1. (Casella's) 3in cups 6.7 arms

Nºs 2 & 3. (Negretti & Zambra's) 3.7in .. 6 7 ..

Nº 4. Adie's 4in .. 5.6 ..

Nº 5. cups 4 in arms 4 in

Nº 6. cups 4 in .. 9 0 in

Nº 7. cups 4 6in .. 11.2in

Nº 8. conical cups 4in .. 5.6in

QUARTERLY JOURNAL

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EDITED BY

JAMES GLAISHER, F.R.S.

1872, January 17.

JOHN W. TRIPE, M.D., President, in the Chair.

Captain Henry Toynbee, F.R.A.S.,
was balloted for and duly elected a Fellow of the Society.

The names of two Candidates for admission into the Society were read.

V. *On Large and Small Anemometers.*
By the Rev. Fenwick Stow.

I was led to begin my investigations into this matter by a wish to ascertain how far a small instrument which had been in my possession two years or so would agree with a large electrical anemometer of the "Kew pattern" recently lent me by Mr. Louis J. Crossley. Subsequently Mr. Symons and Mr. Nunes expressed a wish that I should compare some instruments belonging to them; and to render the experiments more complete, I modified my own instrument in various ways. I must beg, therefore, to express my cordial thanks to those three gentlemen for thus furnishing me with the means of this investigation.

The instruments I used were:—

As a standard, an electrical anemometer, having cups and arms similar in size, shape, and construction, to those of the anemometers recently erected by the Meteorological Committee of the Royal Society. It is arranged to make a contact once for every mile of wind; and the reading

was taken by means of one of Breguet's "Compteurs Electriques." The contact-maker is exceedingly simple, and no failure in its action or that of the "Compteur" has ever occurred.

Of small anemometers I had:—

No. 1, one of Casella's ordinary small instruments, registering up to 505 miles. This instrument has been for some years in the possession of Mr. Symons, but had just been thoroughly cleaned and put in order by the maker, and moved with very little friction.

Nos. 2 & 3, a pair of improved instruments by Negretti and Zambra, quite new and unused. The workmanship, like that of the previous instrument, appeared to be very good, and there was remarkably little friction. As no permanent difference worth mentioning was found between the indications of these two instruments, the mean of the two is used in the Tables of comparison. They were both exposed from September 22nd to October 9th, and during that time one registered 5322 and the other 5334 miles of wind. Occasional differences of 3 or 4 per cent. occurred, chiefly with N.W. winds, the result apparently of the sloping ground beyond the anemometers on that side, and one instrument had gained about thirty miles on the other by the 28th; but they were then interchanged, and the one which had lost, slightly more than made up the deficiency. Generally, however, the agreement was close, and often exact.

No. 4, one of Adie's small anemometers. It had large and somewhat heavy *brass* cups and short arms.

No. 5, the same, with the arms shortened to excess, making them only equal to the diameter of the cups, or the *clear* length of arm only 2 inches.

No. 6. The same, with the arms lengthened to 9 inches. In the case of this and No. 5, the miles given by the scale were altered by calculation, to allow for the difference of the spaces passed through in each revolution.

No. 7. The same, with the arms exactly doubled in length, and with larger but slightly elliptical cups. The figures obtained are given; but the comparison (as in the next case) being thought chiefly a matter of curiosity, the experiments were not prolonged.

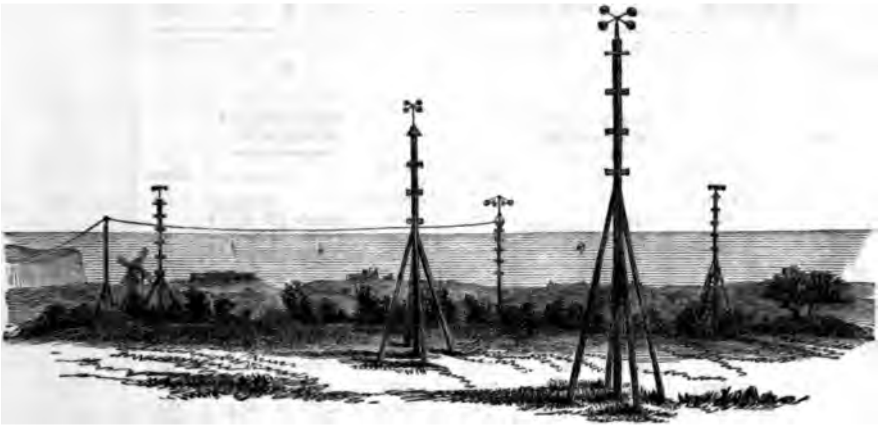
Nos. 8 & 9. The same, with the cups of the same diameter and on arms of the same length as No. 4, but conical instead of hemispherical. The cones first tried were made out of a semicircle of tin, and were of a height nearly equal to the diameter of the base; but these being thought unsatisfactory, new cones made out of two thirds of a circle were substituted, the height being little more than half the diameter. They weighed, owing to the lightness of the material, scarcely half the weight of the hemispherical cups of the same diameter; but, although this was an advantage in light airs, the general result was still less satisfactory, and it does not appear that any thing would be gained by substituting cones for hemispheres.

The arms in all these altered forms of Adie's instrument (except No. 7) were made of small tin tubes, which were found to combine strength with lightness in a remarkable degree. I think, also, that hemispherical cups might be made of tin by the process of stamping. They would be cheaper

and lighter than copper, and if well painted or japanned would be durable enough.

These instruments were set up on poles well steadied by props in a field near my house at Hawsker, about 420 ft. above sea-level. The nature of the situation and the respective positions of the instruments will be explained by the accompanying sketch. No. 7 was tried previously on the post of the extreme left; No. 8 on that of the right, but Nos. 4 & 6 were tried on both these posts. There were no other objects which could interfere with the free passage of the air, and I am satisfied

Anemometers at Hawsker, September 23, 1871.



No. 2, previously No. 4, No. 7 & No. 9; afterwards No. 3 & No. 6. — No. 3, afterwards No. 2. — Standard on a large cast-iron pipe (the cross bars are put in by mistake). — No. 5. — No. 1, afterwards No 4, No. 6 & No. 8.

that the anemometers did not shelter one another. The small instruments were placed so that the lower edge of their cups was level with the upper edge of the cups of the standard, in order to lessen the chance of their being sheltered by it, and no two instruments were less than twenty yards apart. I have gone into these details because I am convinced that too much care cannot be taken to obtain a fair as well as a good exposure for anemometers.

The results of the comparisons I have made are given in detail in the subjoined Tables and diagram. The Tables are arranged according to the mean hourly velocity by the standard during the interval between the observations, and give the total number of miles registered by the standard and by the instrument to be compared with it while the wind maintained that mean velocity, and the ratio in each case of these two amounts, the miles marked by the standard being taken as unity. Observations which gave equal or nearly equal mean velocities of the standard, have, for the most part, been thrown into one. Plate I. exhibits by means of curves the rate of motion of each instrument relatively to the standard at different velocities of the wind.

Comparison of Large and Small Anemometers.

		Description.	Diameter.	Length from cup-centre.
			inches.	inches.
I.	No. 1	Casella's	3 cups	6·7 arms.
II.	Nos. 2 & 3	Negretti and Zambra's	3·7 „	6·7 „
III.	No. 4	Adie's	4 „	5·6 „
IV.	No. 5	Same, with arms shortened	4 „	4·0 „
V.	No. 6	Same, with arms lengthened	4 „	9·0 „
VI.	No. 7	Same, with longer arms and larger cups	4·6 „	11·2 „
VII.	No. 8 / No. 9	Same with conical cups… 2¼ inch. deep / 4 inches deep	4 „	5·6 „
Standard		Kew pattern	9 „	24·0 „

I.

Mean Velocity per Hour by Kew Standard.	Total horizontal Motion of Air according to Standard (A).	Total horizontal Motion of Air according to Casella's (B).	Ratio $\frac{B}{A}$
miles.	miles.	miles.	
3·0	24	20	·833
7·4	280	223	·796
11·0	320	255	·797
12·9	490	371	·757
16·2	406	308	·759
20·2	829	652	·786
24·0	336	260	·774
26·2	420	327	·778
28·0	126	97	·770
30·3	364	287	·788
32·7	180	139	·772
34·8	139	106	·762

II.

Mean Velocity by Standard.	Total horizontal Motion of Air according to Standard (A).	Total horizontal Motion of Air according to Mean of N. & Z.'s two anemometers (C).	Ratio $\frac{C}{A}$
miles.	miles.	miles.	
3·0	24	25	1·041
4·1	58	63	1·086
5·8	75	70	·933
7·4	311	270	·868
11·5	1077	874	·811
14·0	1136	921	·810
16·7	502	394	·785
20·2	829	641	·773
24·3	877	689	·785
26·0	780	591	·758
28·1	352	266	·755
30·3	364	280	·769
32·7	180	135	·750
34·8	139	104	·748

III.

Mean Velocity by Standard.	Total horizontal Motion of Air according to Standard (A).	Total horizontal Motion of Air according to Adie's (D).	Ratio $\frac{D}{A}$
	miles.	miles.	
4·1	58	65	1·120
6·4	246	210	·850
7·1	186	160	·860
7·9	189	162	·857
9·4	478	401	·837
11·2	118	99	·838
13·3	241	200	·830
14·2	1024	832	·812
15·4	592	482	·814
17·8	1091	905	·829
23·2	1043	849	·814
24·6	541	432	·799
27·5	165	126	·764
29·6	148	111	·750

IV.

Mean Velocity by Standard.	Total horizontal Motion of Air according to Standard (A).	Total horizontal Motion of Air according to No. 5. (E).	Ratio $\frac{E}{A}$
miles.	miles.	miles.	
11·0	320	260	·810
13·5	81	66	·815
16·0	272	210	·772
20·2	829	600	·727
24·0	336	241	·719
30·9	216	149	·692
34·8	139	86	·619

Comparison of Large and Small Anemometers (*continued*).

V.				VI.			
Mean Velocity by Standard.	Total horizontal Motion of Air according to		Ratio $\frac{F}{A}$	Mean Velocity by Standard.	Total horizontal Motion of Air according to		Ratio $\frac{G}{A}$
	Standard (A).	No. 6 (F).			Standard (A).	No. 7 (G).	
miles.	miles.	miles.		miles.	miles.	miles.	
7·2	118	101	·856	9·0	664	608	·915
8·6	66	53	·803	13·2	385	344	·893
10·1	163	131	·804	15·7	1054	894	·848
12·7	369	301	·815	18·4	1694	1440	·850
16·3	802	644	·803				
19·0	1123	899	·800				
21·8	262	210	·801				
23·0	268	216	·806				
24·7	371	302	·815				
31·0	96	77	·802				
40·3	141	116	·822				

VII.				VIII.			
Mean Velocity by Standard.	Total horizontal Motion of Air according to		Ratio $\frac{H}{A}$	Mean Velocity by Standard.	Total horizontal Motion of Air according to		Ratio $\frac{H}{A}$
	Standard (A).	No. 8 conical cups (H).			Standard (A).	No. 9 conical cups height—width (H).	
miles.	miles.	miles.		miles.	miles.	miles.	
5·8	75	63	·840	40·8	204	135	·661
7·7	31	23	·742				
10·5	105	71	·676				
14·4	360	246	·683				
19·2	250	150	·600				
29·3	88	50	·568				

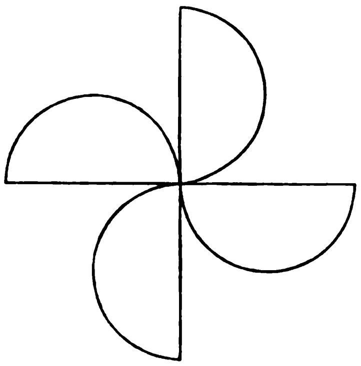
It will at once be seen that the results of these experiments are, in the case of every instrument tried, utterly irreconcileable with Dr. Robinson's dictum, that the centre of each cup travels at one third of the rate at which the wind moves, and that *this law is irrespective of the size of the cups or the length of the arms.* Anemometers with short arms do *not* agree even approximately with the standard, excepting at low velocities; but there is this peculiarity, that, while those which have the smallest cups relatively to the length of arm maintain at all velocities a tolerably even percentage of the motion of the standard, those on the contrary which have large cups and arms move at a high relative speed in very light airs, but fall actually below the others when the wind is high. If the standard be assumed correct, the cups of most of the small instruments move through a space scarcely more than one fourth of that passed over by the wind. Of course it may be asked—which is correct? I do

not know with what instruments Dr. Robinson's experiments were made; but I assume that, as he adopted and recommended the adoption of large anemometers, they ought to be taken as a standard, at least till they are proved incorrect, about the probability of which event I have no means of forming an opinion. Only, as our confidence has been rather rudely shaken in one respect, we, perhaps, need reassuring that the relation between the wind and the cups is not equally mythical.

Note.—Since writing the above, I have had the opportunity of perusing Dr. Robinson's original, and now very scarce, paper on these anemometers. Setting aside theory, the very interesting coincidence of which with the results of his experiments Dr. Robinson himself appears to regard as somewhat fortuitous, it appears that the sole ground on which the supposed relation between the velocities of the wind and of the centres of the cups rests, is the action of a small anemometer placed with its axis in a horizontal position at the end of a long arm, which was caused to revolve by a weight at velocities reading up to, but not exceeding, eleven miles an hour, and which, when afterwards fixed in a vertical position, was found, by counting its revolutions at a velocity of the wind of eleven miles an hour only, to agree approximately with the large instrument. Admirable and ingenious as the experiment was, it seems to me to leave us in the greatest uncertainty (now that it appears that small anemometers do not agree with large ones) whether this relation between the velocities of the wind and of the cups is not applicable to small rather than to large instruments. I have not been able to ascertain whether any subsequent experiments were made which would enable us to speak confidently of the accuracy of large anemometers; but unless this has been the case, I cannot but think that the Meteorological Committee of the Royal Society or other managers of observatories would do well to investigate the matter for themselves.

I ought not to close this paper without attempting to account for the facts observed. I do so with no little diffidence, as I have not gone into the theory of the question, nor am I competent to do so. But may not the explanation be something of this kind? The effect of friction is most easily overcome by the instrument which at a certain velocity of wind has (1) the greatest angular velocity, and (2) the greatest motive power relatively to the amount of friction. The first qualification is possessed by all anemometers with short arms, the second preeminently by those with the largest cups. All small anemometers ought therefore to move faster relatively to large ones at low velocities of wind than at high; and those which have the largest cups should have the fastest relative motion. In some, of course, the advantage of more rapid angular motion may be counteracted in part or entirely by the smallness of the motive power of the cups, or by the excess of friction in the machine; but, as a general rule, it might be expected to be, as I have stated, and my experiments appear to show that it is so.

Next, why, at high velocities, do larger cups move more slowly than small cups on the same length of arm? *E. g.* why does Casella's, with 3-inch cups, beat Negretti's, with cups 3·7 in diam., at velocities of twenty-six miles an hour and upwards? The reason, I believe, is to be found in the fact that, at certain points in each revolution, the cups shelter one another; and it is evident that the larger the cups relatively to the length of arm, the greater the arc through which this interference will take place. So long, indeed, as there is much friction to be overcome, the greater motive power causes a higher speed; but when power is no longer necessary, interference begins to make itself felt. No. 5 was arranged to display an extreme case. It had cups equal to the length of the arms. It will be seen that its ratio of speed diminishes more rapidly as the wind increases than that of any of the other instruments. It would be possible, indeed, to make the arm only half the diameter of the cups by simply fastening the cups together at their edges, as in the following diagram; in which



case a large proportion of the receding cups would always be sheltered, while the advancing cups would, during a portion of each revolution, be clear. I regret that I did not try this form, as I rather doubt whether it would not go backwards. In fact, the speed of the revolving cups depends in some measure on the length of the arm clear of the cups, and not merely on that measured from the centre of each cup to the centre of the axle, which is what I mean in this paper by the term *length of arm*. It is evidently desirable, therefore, that a proper proportion should be observed between the size of the cups and the length of the arm.

This, however, would only secure a uniform rate of motion relatively to the standard, and not the same rate of motion. How are we to account for the great slowness of all small anemometers compared with large ones? Is it that the greater space through which the accelerating force of the wind acts on a cup at the end of a long arm enables a higher velocity to be acquired? Or is the great area of 9-inch cups alone sufficient to enable them to take up more of the wind's velocity than small ones, whenever their angular motion is sufficiently rapid to overcome, to a considerable

extent, the retardation of friction? I think the reason of the result still demands investigation; but about the fact there can be no possible doubt. It is established, not by these experiments alone, but also, as I understand, by those instituted by the Meteorological Committee, and by Mr. Louis J. Crossley, the results of which, however, have not yet, I believe, been published.

It might almost seem then, at first sight, that small anemometers are not more valuable for the purposes of meteorological science than children's windmills. I certainly thought so at the beginning of my experiments, but I have come to a different conclusion. I am convinced that, whatever their faults, they may be made scarcely less correct, if at all, than the best standard instruments. Perhaps I may be permitted to indicate by a few practical suggestions the mode in which, as I believe, this very desirable result may be secured.

1. As the motive power of small cups is so very small, and a very slight increase of friction (from whatever cause) would so seriously affect their motion, I could not advise any cups being made less than 4 inches in diameter.

2. To get a uniform rate of motion relatively to a standard, it is absolutely necessary that the arms should bear a proper proportion to the size of the cups. If a diameter of 4 inches is the minimum size for a cup, 9 inches ought to be the corresponding minimum length of arm. I would propose, in fact, two sizes for small anemometers—the first with 4-inch cups on 9- or 9½-inch arms, and the other with 5-inch cups on 12-inch arms. An inspection of the diagram will show the remarkably flat curve of No. 6, which was of the first-named dimensions, and also of No. 1, in which, although smaller, the same proportion between the cups and the arms was observed. A constant error once allowed for, such an instrument must be as correct as could be desired.

3. A uniform relative rate of motion having been obtained, what should the correction for a constant error be? It ought, of course, to be allowed for in the scale, after having been previously determined by experiment. I can only suggest what I think likely. In the case of 4-inch cups and 9-inch arms, I would allow in a well-constructed instrument about 16 to 18 per cent. Thus, if the arms were 9·2 to 9·4 inches in length from the axle to the centre of each cup, the cups might be assumed to make 300 revolutions for every mile of wind. In the case of the 5-inch cups and 12-inch arms, perhaps 10 per cent. might suffice, so that they might be assumed to make 250 revolutions for every mile of wind. Some means by which anemometers would be as easily compared as barometers or thermometers would be a great gain to meteorology. If arrangements for this were made at Kew (and admirable arrangements were made in the park for the trial referred to), it might go far to rescue a most interesting branch of observation from doubt and disrepute. If small anemometers were made of the right proportions, a very few observations would be necessary for each instrument, some at very low velocities, and some at velocities ranging from ten to twenty miles an hour.

I wish to point out, in support of my sanguine view of the utility of small instruments, that all their curves appear, so far as my observations go, to rise at very low velocities. Referring to the Table of friction-corrections for the instrument at Kew Observatory, I find them so considerable at low velocities, that a small instrument, corrected for its error at fifteen miles an hour, would be actually more correct at low velocities than that standard.

I cannot avoid expressing the wish, in conclusion, that opticians would consult durability more and polish less in the construction of instruments peculiarly exposed to the weather. The weakness of the arms, and the want of solidity in the box, are sources of mishaps even in a moderate gale. Let the cups be light, the arms both light and strong, the axle strong and turning on a point, the bearings smooth, and contrived so as to retain the oil for a long time, the wheel-work simple, the box large, and the graduations capable of being read to the nearest mile of wind from ten yards distance. A very simple electric contact-marker would be an invaluable addition to most instruments. The great essential is proportion, the next strength; and by attention to other details also, very valuable instruments (I do not mean high-priced) would be turned out.

VI. *On the Deep-Sea Thermometers prepared under Admiral FitzRoy's Superintendence.* By Robert H. Scott, F.R.S.

[Read 1872, January 17.]

In a paper by Capt. J. E. Davis, R.N., "On Deep-Sea Thermometers," which has been printed in vol. v. of the 'Proceedings,' it is stated (p. 309) that "at a Meeting of the Committee of the Royal Society, held in the Hydrographer's Room in April 1869, and at which all the appliances for deep-sea sounding were placed before them, the plan of operation for testing the thermometers was discussed . . . .
At the time these experiments were proposed, it was not known that a thermometer had been constructed at the suggestion of Mr. Glaisher, by the late Admiral FitzRoy's directions, with the view of removing the difficulty of pressure."

The author gives a reference to a notice of the instruments in question, which is to be found in the 1st Number of Meteorological Papers, published by authority of the Board of Trade in 1857*, and states that some of them had been used for deep-sea purposes.

I may, perhaps, be excused if I venture to remark that, in April 1869, the history of these instruments was perfectly familiar to many gentlemen interested in the question of deep-sea soundings.

The number of the thermometers of this particular pattern which was

* This reference is quoted by the author of the paper as "Meteorological Report, No. I. 1857."

supplied to the Meteorological Department of the Board of Trade by Messrs. Negretti and Zambra, the makers, was upwards of fifty, and they were supplied to several ships in the Royal Navy, especially those employed on certain well-known deep-sea sounding expeditions; among these I may name H.M.S.—

Cyclops,	Porcupine,	Swallow,
Hydra,	Serpent,	Archer,
Medina,	Gorgon,	Woodlark,
Fox,	Rifleman,	Tartarus.
Bulldog,	Firefly,	

I was not able to find any record of any of these thermometers having been tested in an hydraulic press, and, accordingly, as soon as the Miller-pattern thermometer had been definitely adopted by the Hydrographer, it was resolved to subject one of the old thermometers in the Meteorological Office to the same test as that which the new instruments were made to undergo, in order to see whether or not the construction of the original instruments offered sufficient security against alteration of the shape of the bulb, owing to pressure.

The experiments were carried out on the 28th of September, 1869, at Mr. Casella's, in the presence of Capt. Toynbee and Mr. Strachan, and the results of the testing have been published in the Report of the Meteorological Committee of the Royal Society for 1869.

The concluding sentence of that notice was as follows (p. 32):—

"The foregoing experiments are sufficient to show that the original thermometers, described by Admiral FitzRoy, were good and trustworthy instruments, in so far as regards their capability of resisting pressure."

1872, February 21.

JOHN W. TRIPE, M.D., President, in the Chair.

W. R. Birt, Esq., F.R.A.S., and
Frederick Newton, Esq.,
were balloted for and elected Fellows of the Society.

VII. *On Bourdon's Metallic Barometer.* By the Rev. E. Hill, M.A., Fellow of St. John's College, Cambridge. Communicated by James Glaisher, F.R.S., Secretary.

[Read 1872, February 21.]

This instrument, which was invented by M. Bourdon, is described in Besant's Elementary Hydrostatics, chap. v. (notes), and in Mr. Glaisher's Lecture on the Philosophical Instruments in the Great Exhibition of 1851.

It consists of a thin elastic metal tube of elliptic section, in shape a portion of a circle, closed at its ends and exhausted of air. Alterations in the pressure of the atmosphere are indicated by the ends of the tube approaching towards or receding from each other. I am not aware that any definite explanation of the principle of its action has been offered. M. Bourdon himself appears, from Mr. Glaisher's account, to have given none. The idea which first offers itself to explain the phenomenon is, that since the portion of the surface on the side remote from the centre is greater than the portion on the side nearer the centre, the centripetal pressures will be greater than the centrifugal, so that an increase in the density of the atmosphere, since it will increase the one set more than the other, will tend to further bend the instrument. This explanation, besides taking no account of the elliptic section and tubular construction of the instrument, is wholly fallacious; for it neglects the pressures on the ends: and when these are introduced, it will be found that the forces are all in equilibrium. Indeed, the fallacy is obvious; for if a curved bar of metal could have its curvature increased by an increase of atmospheric pressure, so would a bar of any other elastic substance; and therefore if we consider a similar portion of the air itself, this, too, must have its shape altered, and thus an increase of pressure would alter the stratification of air, and other absurd results would follow.

A partial explanation current is, that it is the principle on which a full sack tends to straighten itself. The meaning of this appears to be, that when the external pressure on the metal decreases, the internal pressure may be considered to increase relatively, and that, therefore, the effect produced will be the same as if air were forced in, and analogous to the effect of filling a sack fuller. An increase of external pressure would produce of course a contrary effect. There is some truth in this explanation. Undoubtedly, the effect of a decrease of external pressure is the same as that of an increase of internal, as may be seen in those cases where the tube, instead of being a vacuum, is connected with the interior of a boiler and used as a manometer to measure the pressure of the steam. Still, as an explanation, this can hardly be considered sufficient or satisfactory. One may ask, why should the full sack tend to straighten? and if it be answered that thereby the capacity is increased, this itself requires proof, and if proved would not show the nature of the mechanical action that goes on. The following discussion will perhaps be found more satisfactory.

Let AB, A'B' (fig. 1), be a section of the tube at right angles to its axis. The resultant pressures at B, B' will be proportional to the major axis AA', and therefore greater than those at A, A', which will be proportional to the minor axis BB'. Hence the effect of the atmospheric pressure on this ellipse will be to squeeze B, B' nearer to each other, and to force A, A' further apart, until the effect of the elasticity called into play is sufficient to balance the forces. In this state an increase of pressure will, of course, still further contract BB' and enlarge AA'.

Fig. 1.

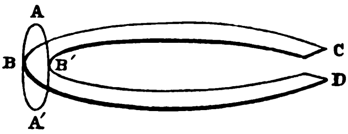
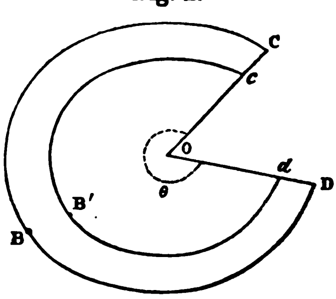


Fig. 2.



Let fig. 2 be a section of the tube by a plane parallel the plane of its circle. Let the radii of the circular arcs C B D, c B′d, be R, r, and let the angle C O D be θ. Let an increase of atmospheric pressure alter them to R′, r', θ' respectively. Now we may regard the lengths of C B D, c B′d as unchanged, since steel, while it will bend readily, lengthens only imperceptibly under ordinary forces.

Hence

$$R\theta = R'\theta',$$

and

$$r\theta = r'\theta'.$$

Subtracting,

$$(R-r)\theta = (R'-r')\theta'.$$

Now $R-r$, $R'-r'$ are the minor axes of the elliptic section before and after the increase of atmospheric pressure. This increase, squeezing up the ellipse, diminishes the minor axis:

therefore $R'-r'$ is less than $R-r$;
therefore θ' is greater than θ,

that is, θ increases with the pressure. But if θ increases, the ends of the tube C and D must approach each other. In like manner, if the pressure decrease, they will open out and recede; and this is what is observed to take place.

It follows, from this investigation, that if the major axis of the elliptic section lay in the plane of the circle, an increase of pressure would make the ends of the tube recede instead of approach, and that if the section were circular, no effect would be produced.

The ellipse is compressed in direction of its minor axis, not merely because the resultant forces in that direction are greater than those along the major axis, but because they can exert a greater moment. If the ellipse were replaced by a rhombus, with elastic joints at its angular points A, B, A′, B′, even equal forces at the angular points would still compress B B′; for the moments about A, A′, tending to bend the joints there, would be greater than those about B, B′. When the section of the tube becomes a circle, not merely do the resultant pressures become equal, but their moments also.

The fact that compression of a curved tube does produce a change in its

curvature may be proved by any one for himself. If the reader chances to have an old kid or leather glove, whose fingers have assumed a curved shape by constant grasping, let him inflate a finger by blowing into it, and then compress it. A change in curvature will usually be seen.

Let us examine in what form the instrument will be most sensitive.

Let b, b' be the lengths of the minor axis of the elliptic section before and after compression. We have then

$$R-r=b, \quad R'-r'=b'.$$

Hence, from above,

$$b\theta=b'\theta',$$

or if $\theta+\alpha$ be put for θ', and $b-x$ for b', so that α is the increase in θ, corresponding to a decrease x in b,

$$b\theta=(b-x)(\theta+\alpha).$$

Neglecting αx, which, being the product of two small quantities, is very small,

$$x\theta=b\alpha;$$

$$\therefore \frac{x}{b}=\frac{\alpha}{\theta}.$$

Hence, for a given compression of the ellipse, the increase in the angle θ varies as θ. Thus, if the change in the angle C O D be used as the indication of the change of pressure, the sensibility will vary as the angle itself, and the instrument ought to be nearly a complete circle. Probably, also, no serious alteration in the indications would result if the shape were not exactly circular. If so, by making it spiral, so that the ends could overlap, it might be lengthened to any extent, and the sensibility greatly increased.

If the change in the arc cd be used as the indication, calling this change s, we shall easily obtain

$$(r-r')\pi=s,$$

and

$$\frac{r'-r}{r}=\frac{b'-b}{b}=\frac{x}{b'},$$

whence

$$\frac{r\pi}{b}x=s;$$

and the sensibility would vary as the radius r, or, inversely as the angle θ, if the length of the tube be constant.

I am informed that in the actual instrument the change in the chord cd is used. The investigation of the sensibility in this case, without Differential Calculus, is rather cumbrous. With it, if y denote this chord,

$$y=2r \,.\, \sin\frac{\theta}{2};$$

$$\therefore \frac{dy}{db}=2\sin\frac{\theta}{2}\cdot\frac{dr}{db}+r\cos\frac{\theta}{2}\cdot\frac{d\theta}{db}.$$

$r\theta$ being equal to the length $cB'd$, is constant, and, from above, since $b'\theta'$, $b\theta$ is also constant. Let, therefore, $r\theta = l$, $b\theta = m$;

$$\therefore \ r = \frac{l}{m} \cdot b;$$

$$\therefore \ \frac{dr}{db} = \frac{l}{m} \cdot \frac{d\theta}{db} = -\frac{m}{b^2};$$

$$\therefore \ \frac{dy}{db} = 2\frac{l}{m} \cdot \sin\frac{\theta}{2} - \frac{mr}{b^2}\cos\frac{\theta}{2};$$

$$= \frac{l}{m}\left(2\sin\frac{\theta'}{2} - \theta\cos\frac{\theta}{2}\right),$$

which measures the sensibility.

If, now, the tube be nearly a complete circle, $\frac{\theta}{2}$ will be nearly π, $\sin\frac{\theta}{2}$ will be small, and the sensibility will be approximately measured by $\frac{l}{m}\theta\cos\frac{\theta}{2}$, or by $\frac{l}{b}\cos\frac{\theta}{2}$. Hence, as before, in a coiled tube whose ends are near together the sensitiveness will increase with the number of coils.

The effect of change of temperature on the instrument may easily be obtained. When, as in the first case, the angle θ, or rather $2\pi - \theta$, is used as basis of measurement, since the radii of the circles, the length of the tube, and the axes of the ellipse, all expand equally, θ will be unaltered, and the indications independent of temperature. In the second case the alterations would be directly proportional to the temperature; for the arc is equal to $(2\pi - \theta)r$. In the third case, where the chord is used, since it is $2r\sin\frac{\theta}{2}$, and θ is unchanged, the alterations will be again proportional to the temperature. This seems to furnish a strong argument in favour of using the indications given by the changes in the angle. The mechanical construction to secure this would be very simple. Changes in temperature will also affect the instrument through the increase of surface increasing the resultant pressure on it; but the effects of this will be very slight. The resultant pressures at A, A', B', B', will increase in the same proportion as the axes of the ellipse, and, therefore, in the same proportion as the metal of the tube. The expansion of steel between 0° and 100° Centigrade being only about ·001 of its length, the error in the pressure indicated would only be about the same decimal of its total amount, and equal, therefore, to about ·03 of an inch of the barometer.

The reader will notice that the elasticity of the steel offers resistance to a change of the circular curvature C B D, as well as of the elliptical A B A'. If the tube were composed of a number of elliptical steel rings like A B A', joined by oiled silk, or some flexible material that will not stretch into a closed tube of the same shape as this instrument, it would give indications in the same manner; the investigations of this article would all hold, and it would only be necessary to calculate the compression

of the ellipse for a given increase in pressure, from which the change in θ follows from the formula above, $\alpha = \frac{\theta}{b}x$.

So, again, if the tube were constructed of parallel elastic wire arcs like C B D, connected by an inelastic membrane, it would give indications; for a compression of the elliptic section would, as above, necessitate a bending of the wire arcs, which their elasticity would resist.

The actual case is a combination of both these. The alteration in shape requires the steel to bend along both the elliptic and the circular sections, and the joint resistance to bending must be overcome.

The actual calculation of the bending produced by a given increase of pressure appears difficult. It would naturally be attempted by the methods that Mr. Besant has used in discussing the equilibrium of a Bent Lamina (Quarterly Journal of Mathematics, vol. iv.); but there the lamina is assumed cylindrical, and the bending is in one direction only, so that the Intrinsic Equation can be used. This case is far more complicated.

VIII. *Note on the New Form of Cloud described by M. Poëy in 'Nature' for the 19th of October*, 1871. By Robert H. Scott, M.A., F.R.S.

[Read 1872, February 21.]

On reading, in 'Nature,' Prof. Poëy's description of the so-called "New Form of Cloud," I at once wrote to the Editor, pointing out that the figure he gave corresponded with one formerly given by Dr. Clouston, as an illustration of the form of cloud he calls the "Pocky Cloud."

My letter appeared in the next Number of the paper; and the succeeding Number contained a third communication on the subject, bearing the signature of "J.," and giving a reference to the 'Philosophical Magazine' for July 1857, where a description of a similar phenomenon is given in a paper "On the Cirrous Form of Cloud," by Mr. W. S. Jevons.

This latter notice of the cloud seems to be the earliest in point of date of publication; but as Dr. Clouston's, given in his 'Explanation of the Popular Weather Prognostics of Scotland,' published in 1867, was illustrated by the best representation of the cloud which has as yet appeared, I wrote to him to ask for other sketches, and have received four, which I submit to the Society, and reproduce one as an illustration.

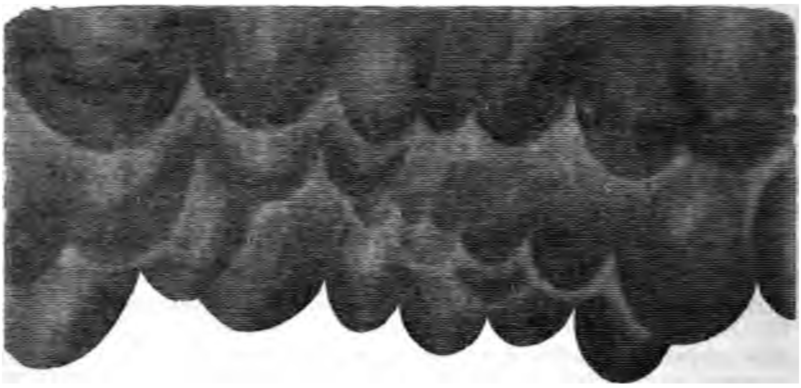
The date of the observation of this cloud has not been preserved; but Dr. Clouston states that it was followed by a storm.

Another sketch is that which has been reproduced in the above-named pamphlet. The observation was made at Stromness Manse, March 5, 1822, and it was immediately followed by a storm, the barometer falling 1·2 inch from 29·5 to 28·3 within 9 hours!

The other two sketches are less detailed.

One was made at Shanghai, August 5, 1871, the observer stating:—

"Came on to blow a strong gale about 15 hours after observation, and blew for 6 days; at same time typhoon, on coast, about 200 miles off." The last sketch was taken in the Mediterranean, November 7, 1871, and the observer reports:—"Had strong breeze for 12 hours; it came on almost at time of observation."



This is copied from a sketch made at the time of the occurrence of the cloud, followed by a storm; but the date is not known.

Dr. Clouston has added nothing to his printed account of the cloud, from which I extract the most important portions.

He says that, "when properly developed, it was always followed by a storm or gale within 24 hours."

"From the sketch it will be seen that this is a series of dark cumulous-looking clouds, like festoons of dark drapery, over a considerable portion of the sky, with the lower edge well defined, as if each festoon or 'pock' was filled with something heavy; and generally one series of festoons lies over another, so that the light spaces between resemble an alpine chain of white-peaked mountains. It is essential that the lower edge be well defined; for a somewhat similar cloud, with the lower edge of the festoons fringed or shaded away, is sometimes seen, and followed by rain only."

He then describes three other observations of the cloud, and concludes as follows:—

"It is remarkable that on these three last occasions (which he cites) the storm burst out in, or veered to, a direction almost exactly opposite to that in which the festooned clouds had travelled. It is difficult, in other cases, to explain why a particular kind of weather follows a particular form of cloud; and it would be premature to attempt to do so in this case, till observations are made with this view; so at present I rather invite than offer explanation; but I may say that as the cumulous cloud is the precursor of coarse weather, so this particular form of it is always the precursor of a gale; and that I cannot look at it without being reminded of Sir J. Herschel's experiment of pouring into a large glass vessel fluids of different densities, which do not mix, and which have different colours.

An undulatory movement impressed on such a system disappears very speedily from the surface of the uppermost fluid, but continues long after to agitate the lower strata. This cloud, then, may be caused by masses of moist air descending, and forcing their way through drier and colder air; for its form suggests air diffusing itself downwards, just as the form of the cumulus, or the steam from the steam-engine, suggests diffusion upwards. If this be so, it shows the moist equatorial current in greater strength than usual, and an uncommonly quick mingling of air-currents, differing in temperature and moisture—the very conditions of a storm. *This cloud is well known, and much dreaded by Orkney sailors.*"

Mr. Jevons's illustration is on a very small scale; he gives an imaginary section of a thunder-cloud near Sydney, in which the form of cloud in question is described as "the appearance of *dropping portions of cloud* at foot or back of storm."

In the paper he gives two experiments to show how the development of the cirrus may be imitated. In Experiment I. he takes a weak solution of sugar, acidified with muriatic acid, and warms it till its specific gravity is ·995. Placing this in a beaker glass, he introduces *beneath* it, by the use of a long-necked funnel, a very dilute solution of nitrate of silver in pure water.

The curdy precipitate of chloride of silver is at once formed in filaments like those of the cirrus, which sinks to the bottom gradually, according as the supernatant syrup becomes cooler and heavier.

In Experiment II. the silver solution is poured in gently *above* the syrup, when "but little cloud at all will be seen to form, even after a considerable length of time; and whatever may happen to be caused by accidental disturbance, will lie in a uniform or streaked flat sheet at the surface, where it is produced, until it finally subsides to the bottom by its own density."

He then remarks:—"It will perhaps have been observed in our experiment No. I. that the streams descending from the upper stratum into the lower often end in little knobs, or drops, or *scrolls* of a peculiar and interesting shape. I do not understand why the descending streams should differ in shape from the ascending ones, which generally, but not always, end in evanescing points, though it might arise from the tendency of chloride of silver to subside, as mentioned before; but it is remarkable that similar appearances are often to be seen on the under surface of dense cirrostratous clouds, especially at the front or tail of a thunder-cloud (as shown in the figure). Sometimes these dropping portions of cloud, or *droplets*, seem to come in contact with dry air, when their well-defined form is destroyed, and a fibrous or fur-like appearance only remains. They appear to be truly portions of *subsiding* cloud."

It will be seen, therefore, that Dr. Clouston and Mr. Jevons agree as to their idea of the formation of the pocky cloud, from the contact of two strata of air in very different hygrometrical conditions; but there is nothing in Dr. Clouston's account to support the view propounded by "J." in 'Nature,' that the phenomenon occurs when the cloud is about to

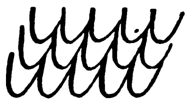
break up. In fact, he expressly points out the modifications in its form which indicate this.

M. Poëy is disposed to attribute the formation of the cloud to electricity; at least I cannot gather any other conclusion from his letter, although he does not expressly state how the electricity acts.

A similar view is entertained by Dr. John W. Moore, of Dublin, a most careful and accurate observer of meteorological phenomena, and especially of clouds. I subjoin a letter which I have recently received from him on the subject:—

"40 Fitzwilliam Square West, Dublin,
November 15th, 1871.

"My dear Mr. Scott,—The letters in 'Nature' on a new (?) cloud were interesting; but the discoverer need not have described it as being very rare. So far as I could gather from his description, it is the form of cloud which I have long noticed under the following conditions:—

"1. In some thunder-storms portions of the *lofty cirrus* and *nimbus* exhibit the appearance in question, the under aspect of the cloud being gathered up in round folds, thus 

"2. Often in cyclonic systems, at the moment when the wind is changing, the *cirro-stratus* layer of the clouds presents a similar form. And lastly, frequently,

"3. in showers of hail the high *cumulo-stratus* becomes puckered, as in the 'new cloud.'

"Considering the above conditions, it appears to me that two elements are required for the production of these phenomena.

"1st. A rapid condensation of vapour, and

"2nd. High *electrical* tension.

"From the above consideration I think it would be better to regard the appearance not as a new form of cloud, but as belonging to clouds of various kinds under certain conditions.

"Yours very truly,
"(Signed) J. W. Moore."

We may, I think, reconcile these two views by the consideration that the contact of two masses of air at very different temperatures, and in very different hygrometrical states, are precisely the conditions which give rise to the development of electrical action in the atmosphere and to thunder-storms, so that a high state of electrical tension would accompany the forcible intermixture of a damp with a dry stratum of air.

I profess myself unable to see how electricity could produce any such modification of the form of a cloud, while we know, by experiment, that the appearance may be reproduced by gradually mixing two fluids of slightly different specific gravities.

It may be interesting to give, in conclusion, one of Dr. Clouston's

notices, showing the value of the cloud as a premonitory symptom of a storm:—

"Another observation of this cloud was on 10th March, 1864, when I noted, in the morning, light fleecy clouds in rapid motion below compact dark ones. At 8.30 in the afternoon the pocky, or festooned clouds, were seen for 10 minutes to the westward, moving before the south wind, probably not more than 300 or 400 yards up; and when they blew past, a more bright and quiet sky appeared in the west, and about 7 P.M. red-coloured aurora.

"Nothing remarkable occurred that night, and next forenoon was so fine and bright, that I was induced to go to Stromness, about six miles off, to bring home a member of my family, though still under some dread of the festoons.

"We started for home in an open gig, nearly twenty-six hours after their appearance, during a flat calm, and I began to doubt if there would be any storm at this time; but I soon paid for my incredulity, for at 5.30, or just about twenty-six hours after the festoons, such a sudden storm of N.N.W. wind burst in our faces, accompanied with quantities of wet snow, that though we persevered for the remainder of the six miles we had to drive, it was decidedly the worst weather I have travelled in for more than half a century; and it was only after the breaking of an umbrella, and losing of a shawl, that we reached home in a wrecked condition. I found by the registering anemometer that the wind suddenly commenced thus, with a velocity of nearly sixty miles an hour, and continued so till after midnight. This obliges me slightly to modify my former opinion, that 'it was always followed by a storm or gale within twenty-four hours;' for on this occasion it was *twenty-six* hours afterwards. On 10th the barometer stood at 29·236 in the morning, and 28·978 in the evening, and on 11th at 28·938 in the morning, and 29·108 in the evening. On 10th the wind was south-west, force, 1 in the morning; and south, 2 in the evening; and on 11th west-south-west, 1 in the morning; and north-west, 4 in the evening" *.

IX. *Notes on the Thunder-storms reported to the Meteorological Office during the Six Years* 1866–71. By ROBERT H. SCOTT, M.A., F.R.S.

[Read 1872, March 20.]

I FEEL that an apology is due to the Society for bringing before it such a meagre Table as that which I now submit; but, such as it is, I venture to hope that it may break the ice for really important and thorough discussions of the subject, to be carried out by our future Assistant-Secretary, and based upon the Schedules furnished to the Society by its observing Fellows.

The subject of thunder-storms has for some time attracted the attention

* See 'Symons's Magazine' for July 1868 for remarks on this form of cloud.

of foreign meteorologists, especially in countries where the various crops are subject to serious damage from hail-storms. It cannot have escaped the notice of any one travelling abroad that insurance against hail is to the full as prominently advertised, at least in Germany, as fire insurance.

The 'Atlas des Orages,' which has for some years past been published by the Paris Observatory, contains much important information on the frequency, the usual tracks, and the rate of advance of thunder-storms in France.

In Norway, the able Director of the Meteorological Institute, Prof. H. Mohn, has instituted a staff of observers, and has published in his annual notices "Om Tordenveir i Norge," most valuable contributions to the history of these phenomena. The value of the results he has obtained is enhanced by the great extent of the kingdom of Norway, which stretches over 14 degrees of latitude.

The Swedes are moving in the same direction, and Dr. Hildebrandsson,

Observations of Thunder, Lightning, or Thunder and Lightning (both),

Months.	Nairn.				Aberdeen.				Leith.			
	T. only.	L. only.	T. & L. or Thunder-storms.	Total.	T. only.	L. only.	T. & L. or Thunder-storms.	Total.	T. only.	L. only.	T. & L. or Thunder-storms.	Total.
January	...	3	...	3	...	...	...	...	1	...	...	1
February	...	...	...	...	...	...	...	...	1	...	...	1
March	...	...	...	...	...	...	...	...	...	...	...	...
April	...	...	1	1	2	...	...	2	1	...	1	2
May	1	...	...	1	...	...	...	...	1	...	...	1
June	1	...	...	1	2	..	1	3	2	...	2	4
July	1	...	1	2	6	...	1	7	2	...	...	2
August	4	2	...	6	4	...	1	5	3	...	2	5
September	2	1	...	3	3	1	...	4	2	...	...	2
October	...	...	...	...	...	...	...	...	...	...	...	...
November	...	1	...	1	...	...	...	...	1	...	...	1
December	...	1	...	1	...	...	...	...	...	...	...	...
Total for the 6 years	9	8	2	19	17	1	3	21	14	...	5	19

Months.	Holyhead.				Valencia.				Roche's Point (for 4 years, 1868-71 only).			
January	...	...	...	...	8	2	3	13	...	2	1	3
February	...	1	...	1	2	3	...	5	...	2	...	2
March	...	...	...	...	1	4	...	5	...	1	1	2
April	...	...	...	...	...	3	...	3	...	...	...	...
May	...	...	...	...	...	2	...	2	...	...	1	1
June	1	1	...	2	3	...	...	3	1	...	1	2
July	...	...	...	...	...	1	2	3	2	...	3	5
August	1	1	...	2	1	2	...	3	...	4	1	5
September	...	1	...	1	5	4	...	9	...	1	3	4
October	...	...	...	...	4	4	...	8	...	1	2	3
November	...	1	...	1	1	1	...	2	...	1	1	2
December	...	...	...	...	2	6	...	8	...	4	...	4
Total for the 6 years	2	5	...	7	27	32	5	64	3	16	14	33

of Upsala, has commenced inquiries similar to those carried out at Christiania.

The journal of the Austrian Meteorological Society contains numerous communications on the subject; and two years ago Prof. Jelinek laid before the Academy at Vienna a return, analogous to that which I now bring before the Society, showing the number of days on which thunder-storms had been reported at each of the Austrian stations.

It behoves us, therefore, to be up and doing in the Meteorological Society, if we do not wish to find ourselves entirely left behind by the progress of modern meteorology. We have had a very good example shown us by the Scottish Meteorological Society in this especial direction; for in Vol. II. of their Journal (at p. 239) we find a paper by Mr. Buchan on the returns of thunder-storms from the Scottish stations for a period of 12 years.

The Table shows the number of days on which—1, Thunder; 2, Light-

reported to the Meteorological Office by Telegraph, from 1866 to 1871.

Scarborough.				Yarmouth.				Ardrossan.				Greencastle.			
T. only.	L. only.	T. & L. or Thunder-storms.	Total.	T. only.	L. only.	T. & L. or Thunder-storms.	Total.	T. only.	L. only.	T. & L. or Thunder-storms.	Total.	T. only.	L. only.	T. & L. or Thunder-storms.	Tota
...	...	...	...	...	1	1	2	...	...	...	...	...	1	1	2
1	...	...	1	...	...	...	...	...	1	...	1	...	...	...	...
1	1	2	4	...	...	...	...	1	1	1	3	...	...	...	...
2	...	2	4	1	...	1	2	1	1	...	2	...	1	...	1
4	1	...	5	4	...	1	5	1	...	...	1	...	...	...	...
4	1	...	5	6	...	2	8	...	...	...	...	3	...	...	3
10	2	...	12	7	...	...	7	4	...	1	5	1	...	...	1
3	...	1	4	4	...	...	4	3	...	2	5	2	1	...	3
2	1	2	5	6	1	...	7	...	1	...	1	...	...	...	...
1	...	...	1	1	1	...	2	...	3	...	3	...	...	...	...
...	...	...	...	...	...	...	...	...	4	...	4	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1
28	6	7	41	29	3	5	37	10	11	4	25	7	3	1	11

Penzance.				Plymouth.				Portsmouth.				London.			
...	3	...	3	...	1	1	2	...	...	1	1	...	2	...	2
...	1	1	2	1	1	...	2	...	...	...	...	...	3	...	3
...	...	...	...	1	...	...	1	...	...	1	1	...	...	...	...
...	...	1	1	...	...	...	...	...	...	...	...	...	5	2	7
...	2	...	2	...	...	2	2	3	1	2	6	...	4	5	9
...	1	...	1	...	...	...	...	4	...	3	7	2	2	7	11
1	3	1	5	1	1	1	3	1	1	2	4	7	1	10	18
...	...	1	1	...	1	1	2	3	3	3	9	1	9	5	15
1	1	...	2	...	...	4	4	5	...	3	8	...	6	7	13
...	1	...	1	...	...	...	...	1	...	...	1	...	1	1	2
...	1	2	3	...	1	...	1	...	...	...	...	...	1	1	2
1	2	2	5	...	1	...	1	1	...	...	1	...	2	...	2
3	15	8	26	3	6	9	18	18	5	15	38	10	36	38	84

ning; 3, Thunder and Lightning together, or Thunder-storms, have been reported by the observers at the Telegraphic-Reporting Stations in connexion with the Meteorological Office.

The stations are too sparsely scattered over the country for it to be advisable to throw them together into groups representing the various districts, as Mr. Buchan has done, and thereby to give additional certainty to these indications of periodicity.

It must be remembered that the telegraph-clerks who have furnished the reports are engaged in their offices all day long, and are not as well situated for recording every occurrence of thunder and lightning as are, for instance, the observers of the Scottish Meteorological Society, twenty eight of whom, out of eighty given in the last Number of their journal, are gardeners.

It has not been thought worth while separating the three classes of phenomena, and I shall therefore only speak of the total number of observations of all kinds.

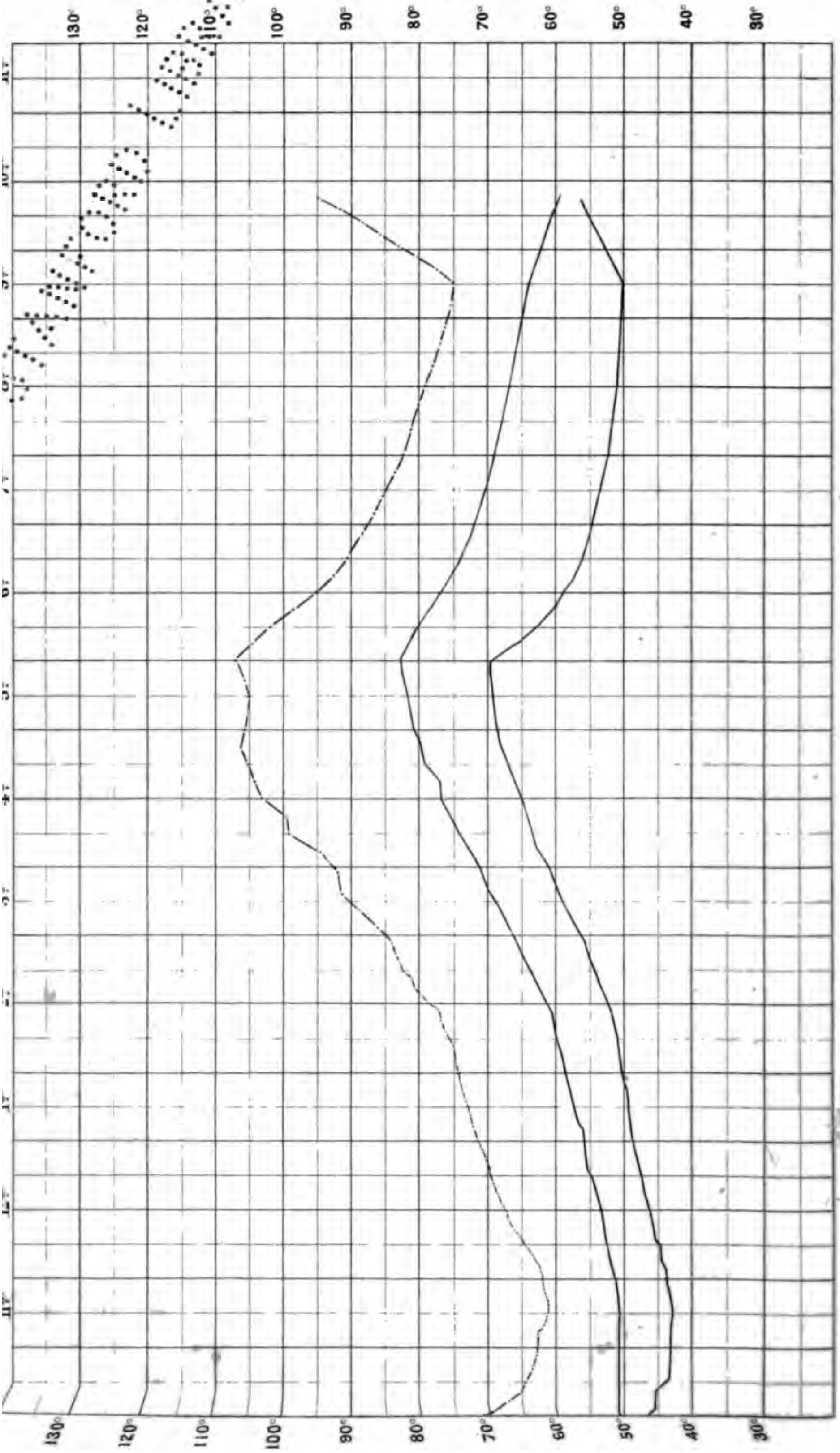
It will be noticed that most of the stations show the summer maximum, which is especially marked in London; a striking exception is, however, to be found at Valencia, where the absolute maximum falls in January, a second maximum occurring in September.

This is the only station from which the data resemble those given by Mr. Buchan for "Thunder with Lightning" for the islands and N.W. division of Scotland.

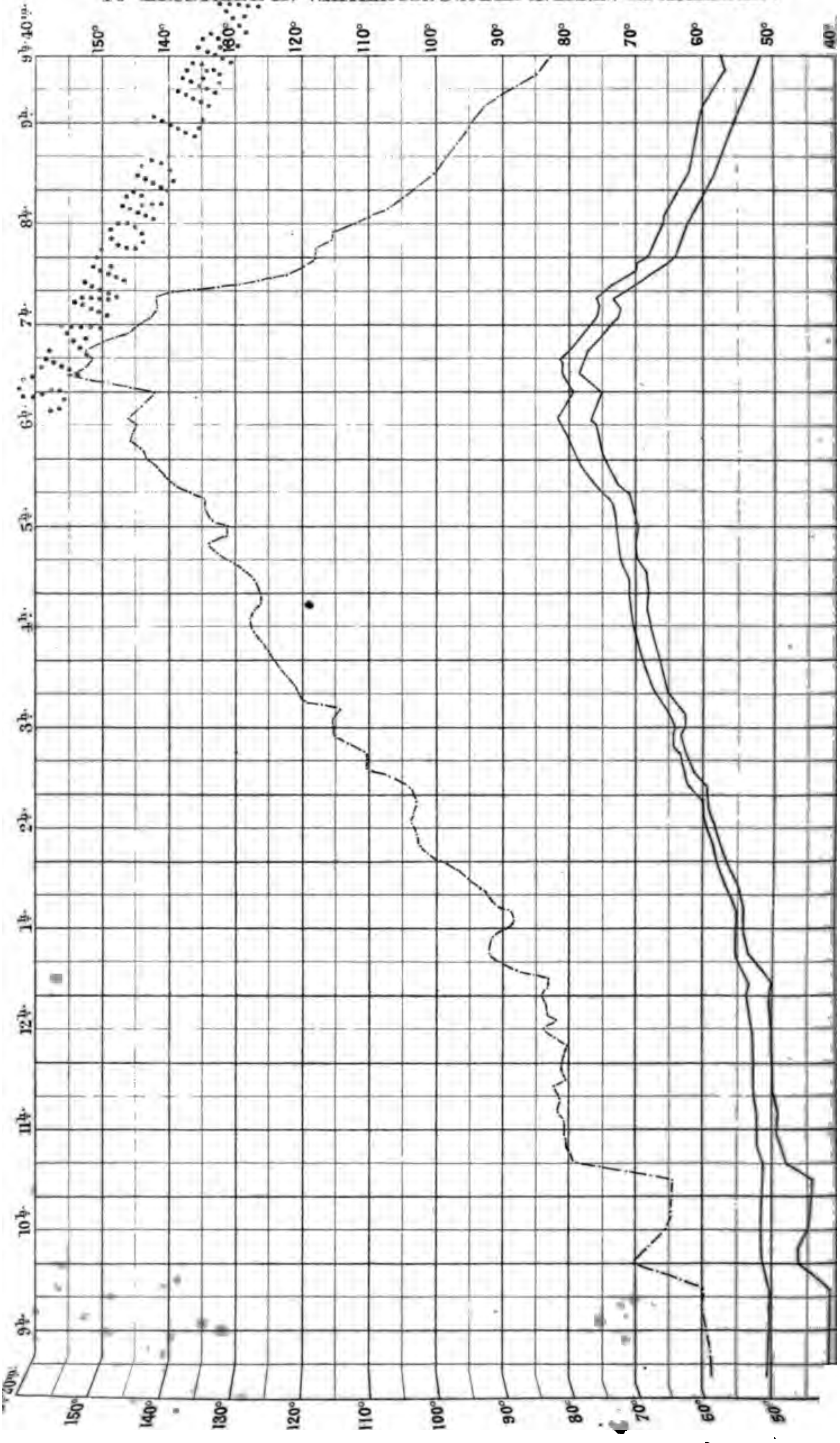
The figures for Roche's Point, for the four last years of the period, exhibit a winter maximum; but the absolute maximum occurs in summer.

The circumstance that many of the reports from the east coast of England are of thunder only, is simply attributable to the fact that the thunder-storms have been dissipated before they reached the coast.

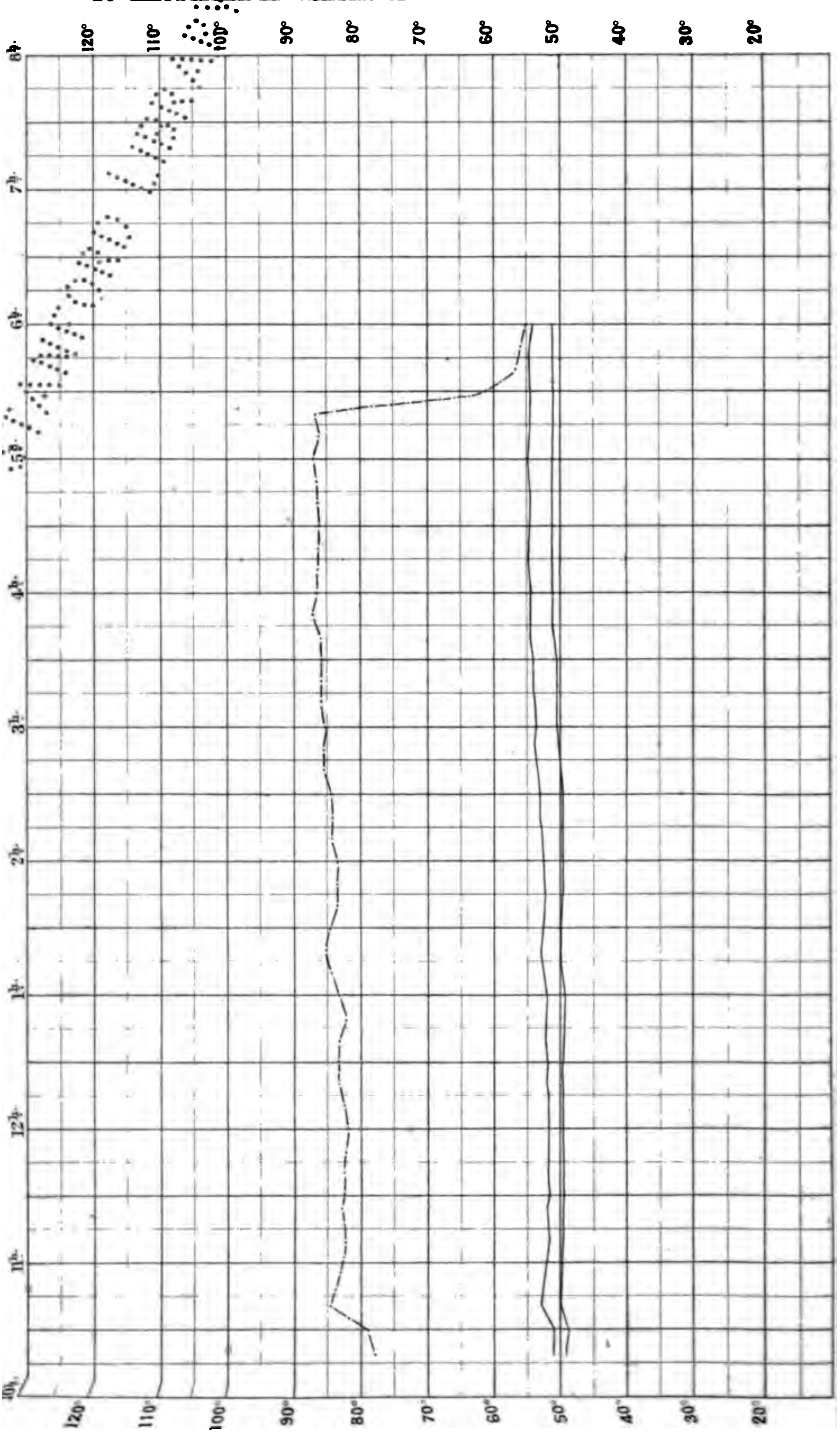
TO ILLUSTRATE M^r. WHITEHOUSE'S PAPER ON A NEW HYGROMETER.



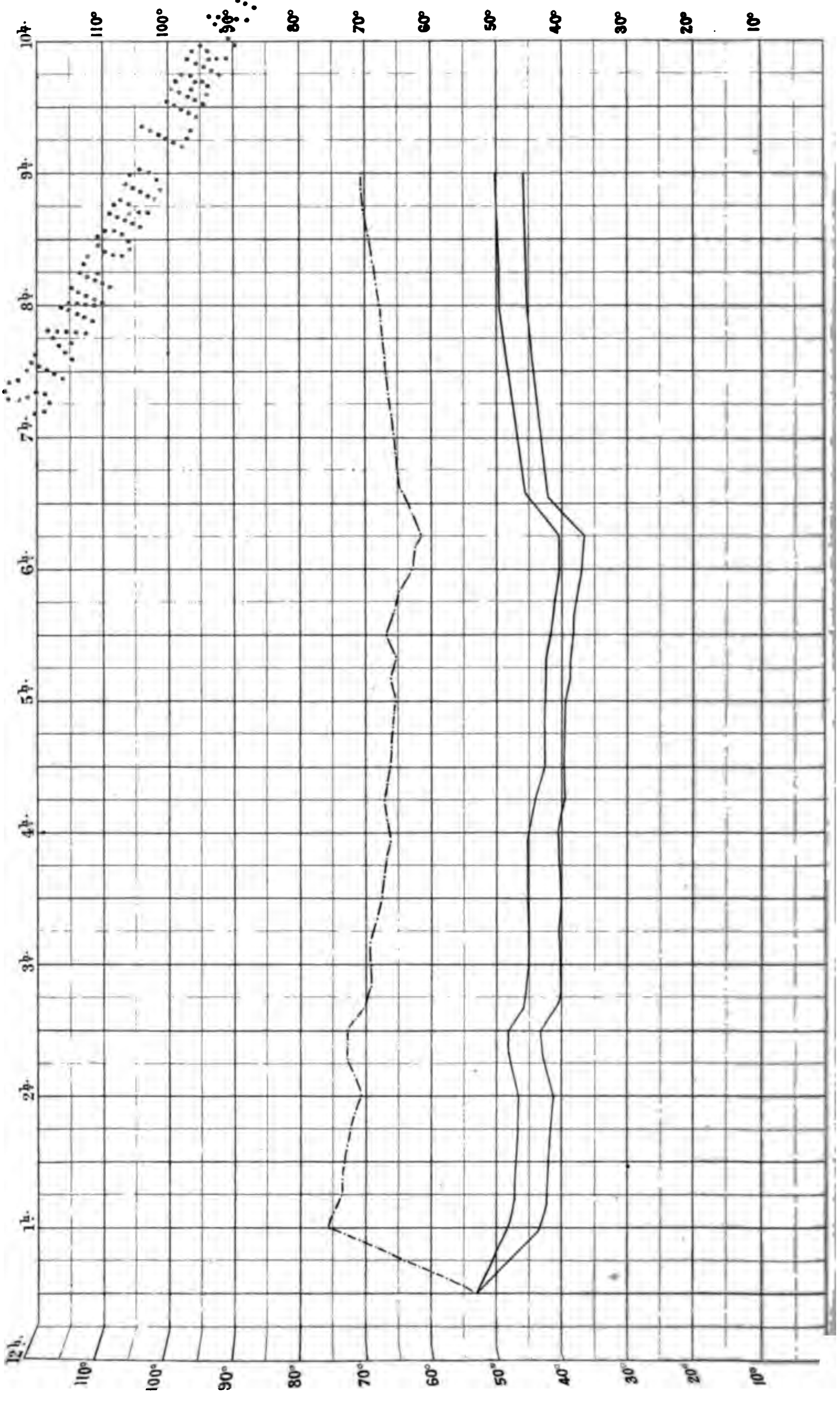
TO ILLUSTRATE MR. WHITEHOUSE'S PAPER ON A NEW HYGROMETER.



TO ILLUSTRATE Mr. WHITEHOUSE'S PAPER ON A NEW HYGROMETER.



TO ILLUSTRATE MR WHITEHOUSE'S PAPER ON A NEW HYGROMETER.



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X. *On a New Hygrometer.* By E. O. WILDMAN WHITEHOUSE.

[Read March 20, 1872.]

UP to the present time it must be admitted that the use of the wet- and dry-bulb thermometers has been found to offer the most practically available mode of obtaining hygrometric measurements, and, indeed, has furnished the only means of procuring a continuous record.

Continued observations and some years of experience at the various observatories in which this method has been employed, seem to throw serious doubts on the value of the indications at or near the freezing-point, below which, unless under careful personal manipulation, they either cease or become unreliable and, for the purpose of continuous records, useless.

In a conversation which the author had with the Director of the Meteorological Office some months ago, the question arose whether any thing could be suggested to remedy this inconvenience. It was obviously inadmissible to make any addition to the water to prevent its freezing, or to substitute any other fluid for it on the wet bulb, as it would then cease to be a test for the purely hygrometric capacity of the air. It became therefore necessary to fall back in another direction (the opposite), and to find some hygrometric body which should readily and rapidly absorb moisture from the air, and at the same time afford some means of measuring and recording the amount of such absorption. The fused chlorides of zinc or calcium seemed promising as very active agents, absorbing very powerfully and rapidly, at all temperatures, upon their exposed surfaces, and allowing by gravity a ready escape of the fluid hydrate for weight or measurement; yet no means presented itself of accurately regulating and maintaining the exact extent of surface of the solid exposed for absorption, nor could the material itself be easily renewed when required.

It seemed essential to the accuracy and practical utility of any instrument designed for this purpose:—

1st. That a fixed and invariable extent of surface should at all times be exposed for absorption of moisture;

2nd. That the apparatus should be simple, inexpensive, and not inconvenient in use;

3rd. That the hygrometric substance should be continuously and steadily renewable; and above all, if it were possible;

4th. That the measurement should be effected thermometrically.

No solid hygrometric substance seemed capable of meeting these

requirements; but all the conditions seemed likely to be fulfilled by the use of concentrated sulphuric acid*.

This would admit of being spread in an exquisitely fine film over the surface of the bulb of a thermometer by means of a glass capillary siphon, of which one end should rest on the upper part of the bulb, while the other end dipped into a reservoir of acid. A continuous supply could be maintained for any required length of time by suitable arrangements.

The absorption of moisture would necessarily be attended by a rise in temperature, and this would be proportioned to the amount of hygrometric moisture absorbed, while the hydrated acid, having fulfilled its office, would fall in drops from the bulb into any tube or reservoir placed for the purpose.

An instrument has been designed by the author for the purpose of testing

* Since the paper was read, Prof. De la Rive has published notices in the 'Archives des Sciences Physiques' and in the 'Philosophical Magazine;' as the latter of these is not very long, it seems advisable to reprint it.—Ed.

"*On a New Hygrometer. By* A. DE LA RIVE.

"*To the Editors of the Philosophical Magazine and Journal.*

"GENTLEMEN, "Geneva, June 1, 1872.

"HAVING just seen, in volume xx., No. 132, of the 'Proceedings of the Royal Society,' the description of a 'new hygrometer' by Mr. Wildman Whitehouse, allow me to state that an instrument founded on exactly the same principle was proposed by me in 1825. My paper on the subject first appeared in the *Bibliothèque Universelle* of Geneva (vol. xxviii. p. 285); and the following extract of it was published the same year by Gay-Lussac in the *Annales de Chimie et de Physique* (vol. xxx. p. 87).

"I remain, Gentlemen, yours &c.,

"A. DE LA RIVE.

"*Translated from the Annales de Chimie et de Physique* (vol. xxx. p. 87).

"I plunge the bulb of a delicate thermometer into concentrated sulphuric acid, and then suddenly withdraw it with a slight shake, so as to leave only a thin film of acid on the surface of the bulb. The thermometer immediately rises several degrees; and after remaining an instant stationary, it begins to fall. I next determine the number of degrees the thermometer rises, under the same circumstances, when the atmosphere is completely saturated with moisture; the difference between the two results will furnish the exact relation between the tension of the vapour contained in the atmosphere at the moment of my observation and its tension when the atmosphere is in a state of perfect saturation. For instance, the thermometer, at the moment of the bulb being introduced into the sulphuric acid, indicated 12° Réaumur. On being withdrawn and exposed to the air it rose to 25°·5, or 13½°. Placed under a receiver in an atmosphere of perfect saturation at the same temperature of 12° it rose to 27°, or 15°. Hence the ratio of 13½ to 15 expresses the relation that exists between the tension of the vapour contained in the air and the tension of saturation for a temperature of 12°. Now the ratio of 13½ to 15 is equal to that of 90 to 100; and it will be found, by referring to Gay-Lussac's Table, published in the *Traité de Physique Expérimentale et Mathématique* of Biot, that the degree of De Saussure's hygrometer which corresponds to the tension of 90 is 95·43. During the above experiment the reading of the same hygrometer was 95·50.

"For any other temperature than that of 12° R., and for the same degree of De Saussure's hygrometer, the rise of the thermometer will be proportional to the temperature of the atmosphere, since the quantity of aqueous vapour the air is capable of containing depends mainly on its degree of temperature. It would therefore appear to be necessary to ascertain the variation of temperature, produced by air in a state of saturation, for each degree of the thermometer, were it not that a series of experiments have convinced me that it was sufficient for all practical purposes to determine the rise of the thermometer, in the case of a saturated atmosphere, for two extreme points only, such as 0° and 20° R., and to distribute this difference equally between the intermediate degrees. It also appeared to

this principle, a description of which he has now the honour of laying before the Society.

A short notice of this instrument has already been laid before the Royal Society ('Proceedings,' No. 132), some of the descriptive parts of which have been incorporated with the present paper, together with the results of a long series of observations and experiments subsequently made.

It consists essentially of three thermometers, of like construction, fixed side by side upon a suitable stand, and used as a "wet bulb," a "dry bulb," and an "acid bulb" respectively.

The wet and dry bulbs need no explanation. The acid bulb is provided with a reservoir in the form of a double-necked or "Woulf's" bottle, through one of the necks of which a tube passes down to within half an inch of the bottom of the bottle; this tube is fixed air-tight into the neck, and through it is passed the capillary siphon, which thus draws the acid always from the same level, viz. the open bottom of the tube; thus whether the reservoir be full or nearly empty, the available surface is always the bottom of this tube. It has been so arranged that the level of this surface shall be just a little above the spot of the thermometer selected for the delivery of the acid.

The capillary siphon, one of whose legs should be somewhat longer than the other, slowly and steadily delivers the acid to the bulb. The second neck of the bottle allows the renewal of the acid without disturbance of the siphon; and the experience already gained in the use of this instrument has shown that the supply of acid may be made continuous for any required length of time; and that notwithstanding the slight variations of flow which occur in its action, the supply to the thermometer will be sufficiently equable. The length of the siphon and the size of its capillary bore, together with the difference of level between the surface of the fluid and the point of delivery on the bulb, will determine the rate of flow of the acid.

It is clear that a too rapid and continuous stream of acid at the temperature of the air, or a too scanty supply, would diminish the readings; yet it is found that practically there may be a pretty wide range of variation in the supply of acid, within which no essential change in the sensi-

me that the variations of the thermometer, at the moment of its being withdrawn from the acid, were proportional to the tensions of the vapour at the above temperatures.

"It might appear probable at first sight that, however small the quantity of vapour contained in the atmosphere, there would always be a sufficient quantity of moisture to saturate the acid film spread over the surface of the bulb, and consequently to develope in every case an equal quantity of heat. My answer to that objection is, that there appears to exist a sort of opposition between the affinity of the acid for moisture and the tendency of water to remain in a state of aqueous vapour, which increases in proportion to the dryness of the atmosphere. It follows that the greater the quantity of moisture contained in the atmosphere the greater the rapidity with which it will be condensed by the acid, and consequently the greater the heat developed. The thermometer in each case will continue rising until the cooling influence of the surrounding air becomes sufficient to neutralize the quantity of heat due to the condensation of moisture, and the moment at which that effect is produced must depend upon the greater or less quantity of vapour the atmosphere contains."—*Philosophical Magazine*, Fourth Series, vol. xliii. p. 514.

bility of the instrument is noticed. For a cylindrical bulb, having one square inch of surface, one drop per minute is sufficient, though the time may range from twenty to eighty or ninety seconds without loss of sensibility, the time being noted as the hydrated acid, after having fulfilled its office, falls drop by drop from the bulb.

The quantity of acid consumed is very small, not amounting to 4 oz. by weight in the twenty-four hours, and at a cost not exceeding one farthing per diem. Concentrated acid may be easily procured free from lead and of uniform density (guaranteed 1·850), in convenient and moderate-sized stone jars, made for the purpose, at one penny per pound.

The temperature of the acid in the reservoir is necessarily that of the surrounding air; the elevation of temperature shown by the acid-bulb thermometer is due to, and seems to be strictly a measure of, the amount of moisture absorbed by the film of acid spread over the surface of the bulb (say, 1 square inch), continuously supplied at a uniform rate in its concentrated state, and as constantly passing off hydrated.

While, therefore, this instrument is, like Mason's, intended to measure the amount of hygrometric moisture in the air, and to do so thermometrically, it yet is, in its principle and in its operation, essentially of an opposite character.

The action of the wet-bulb thermometer depends upon, and is a measure of, the amount of sensible heat absorbed and rendered latent by evaporation of water from its surface; the reading is always below that of the dry bulb, and this difference disappears gradually as the atmospheric humidity approaches perfect saturation.

The action of the acid bulb, on the contrary, depends upon, and is a measure of, the amount of latent heat rendered sensible by the condensation of vapour into water on the surface of the bulb, and by the combination of this water with the concentrated acid. The reading is always above that of the dry bulb, and this difference will disappear only in a perfectly dry atmosphere.

It would seem that a hygrometer on this principle can hardly be embarrassed by the most intense frost; for the concentrated acid cannot freeze either in the reservoir or in the siphon; and the instant it absorbs any moisture from the atmosphere, it undergoes an immediate rise of temperature. It is more than probable, indeed, that even after the waste acid has dropped from the bulb in intense frost, it will still be found to be in too concentrated a state to admit of freezing.

The sensibility of the acid bulb is very great, and its indications are at their maximum when those of the wet bulb are closing up and disappearing; it seems probable, therefore, that, without superseding, it may advantageously supplement that instrument, affording reliable indications when that fails, and offering at all times a comparative and control test of considerable value.

Of course photothermograms may as readily be obtained from the acid as from the wet-bulb thermometer, and thus the practical utility of the instrument may be soon tested.

It has not been within the author's power to determine accurately the value of the readings of the acid-bulb thermometer; nor, indeed, does he desire to attempt it, preferring to leave it in the hands of those more skilled in that department of meteorological science, and more at home in the necessary calculations.

A careful consideration of the principle on which this instrument works, and an examination of the results obtained, comparing them with the dew-point and wet-bulb observations, have led the author towards the conclusion that the difference between the dry and acid bulbs will be found to be, more or less strictly, a measure of the amount of watery vapour present in the air at the existing temperature, and that the amount of this difference in degrees, divided by some factor (yet to be ascertained), will give an expression of the amount of water, in grains per cubic foot, present in the air at that temperature.

The accompanying diagrams give the results of four out of fourteen days' observations made or personally superintended by the author; they do not profess to show more than a good preliminary "run over the ground," to handle the instrument and see how it works; they have not even been made in pursuance of any special plan of examination.

One or two trials have been made for extremes of moisture and dryness up to the limits of the apparatus available for the purpose. These have been made under a glass shade, as the only means at hand of commanding the desired conditions of dryness or saturation of air, with any range of temperature.

The Tables of observations have, for greater convenience of examination, been thrown into the form of diagrams, in which the two dark lines denote the wet and dry bulbs respectively, and the dotted line the acid bulb.

Some peculiarities connected with the rate of acid supply deserve notice.

The range within which different rates of supply give sensibly equal readings may vary in some instances as much as 4 to 1, or even more; and two similar thermometers have been under simultaneous observation, all other conditions alike, whose rates of acid-supply respectively were as 10 to 1, while the difference between their excess readings was as 11 to 10.

Experiments made at rates of supply varying from one and a half to three hundred seconds per drop have seemed to warrant the inference that, under the existing conditions, the rate of increase of temperature in the acid, per second of exposure, is at its maximum at the instant after its escape from the siphon, and that it continues to receive, in a decreasing ratio, fresh increments of heat. The acid, however, is delivered upon the bulb at the temperature of the air, a point always below, sometimes very far below, that of the bulb itself, so that the upper part of the bulb is actually cooled by first contact with the acid, which afterwards heats the lower part so freely. A very simple plan has presented itself of saving this waste of heat, by making the acid warm itself up to the proper degree before its delivery upon the bulb. This idea has not yet, however, been incorporated with the instrument.

A short and easy experiment will show at once the principles of this hygrometer and some of the peculiarities of its action.

If a thermometer be plunged into a bottle of sulphuric acid, and allowed to remain there, it will merely show the temperature of the surrounding air.

Withdraw it carefully, and observe for ten minutes, holding it horizontally and moving or turning it on its axis, so that the drop of acid clinging to it may not fall, but be retained, and by moving may have a constantly fresh surface exposed to the air for the absorption of moisture.

Within the first minute it will have risen rapidly, attaining (if the instrument be sensitive) fully half its maximum elevation of temperature.

It will continue to rise, though more and more slowly, till about the fourth minute, when it will have attained its maximum, the amount of this depending, of course, upon the hygrometric condition of the atmosphere.

At this point it remains for nearly three minutes almost unchanged, the slight increments of heat just balancing the cooling effects of the surrounding air.

By the eighth minute, and not till then, has it begun to fall, and that very slowly; nor is it until the tenth minute that the fall becomes at all rapid.

It is believed that in the careful study of the above points will be found the explanation of the very wide range within which the rate of supply may vary without impairing the validity of the readings of the acid thermometer.

Thus, it is now easy to understand some observations which, at first sight, seemed perplexing and anomalous, viz. that on taking away the acid siphon, under some circumstances, an actual rise of temperature took place, and several minutes elapsed before the thermometer fell below the point at which it stood at the time when the supply was stopped.

Two Experiments.—Thermometer in hand, bulb each time once plunged into acid, and observed.

Minutes.	Degrees.	Rise or Fall per minute indicated by + or −.	Minutes.	Degrees.	Rise or Fall per minute indicated by + or −.
0	52°	= 0°	0	48°	= 0°
1	62	= +10	1	63	= +15
2	66	= + 4	2	70½	= + 7½
3	69	= + 3	3	73½	= + 3
4	70	= + 1	4	75	= + 1½
5	69½	= − ½	5	75	= 0
6	69½	= 0	6	75	= 0
7	69½	= 0	7	75	= 0
8	69½	= 0	8	74½	= − ½
9	69	= − ½	9	73½	= − 1
10	67½	= − 1½	10	71	= − 2½

Three Series of Readings of Acid Thermometer after cutting off the supply of acid.

Seconds.	Degrees Fahr. Rise or Fall indicated by + or −.	Seconds.	Degrees Fahr. Rise or Fall indicated by + or −.	Seconds.	Degrees Fahr. Rise or Fall indicated by + or −.
0	$+0^\circ=72^\circ$	0	$0^\circ=76\frac{1}{2}^\circ$	0	0°
15	$+\frac{3}{4}=72\frac{3}{4}$	15	$0=76\frac{1}{2}$	30	0
30	$+1=73$	30	$+\frac{1}{2}=77$	60	$-\frac{1}{4}$
45	$+1\frac{1}{4}=73\frac{1}{4}$	45	$+\frac{3}{4}=77\frac{1}{4}$	90	$-\frac{1}{2}$
60	$+1\frac{1}{2}=73\frac{1}{2}$	60	$+1=77\frac{1}{2}$	120	$-\frac{3}{4}$
75	$+1\frac{3}{4}=73\frac{3}{4}$	90	$+1=77\frac{1}{2}$	180	$-2\frac{1}{4}$
90	$+2=74$	120	$+\frac{3}{4}=77\frac{1}{4}$	240	$-4\frac{1}{4}$
105	$+2=74$	145	$+\frac{1}{2}=77$		
120	$+2=74$	160	$+\frac{1}{4}=76\frac{3}{4}$		
135	$+2=74$	180	$-\frac{1}{4}=76\frac{1}{4}$		
150	$+2=74$	225	$-1=75\frac{1}{2}$		
165	$+1\frac{3}{4}=73\frac{3}{4}$	240	$-1\frac{1}{2}=75$		
180	$+1\frac{1}{2}=73\frac{1}{2}$				
195	$+1\frac{1}{4}=73\frac{1}{4}$				
210	$+\frac{3}{4}=72\frac{3}{4}$				
225	$+\frac{1}{4}=72\frac{1}{4}$				
240	$0=72$				
300	$-2=70$				
Dropping at the rate of 8 seconds per drop.		Dropping at the rate of 16 seconds per drop.		Dropping at the rate of 28 seconds per drop.	

EXPLANATION OF PLATES.

Plate II. February 24.

Instrument placed under glass shade, the air being artificially dried by enclosing at same time several small glass troughs of concentrated sulphuric acid.

The temperature of the room and instrument raised gradually from 10 A.M. till 5.20 P.M., at which time the stove-fire was extinguished and the room allowed to cool down. From 10 A.M. till 3 P.M. observations were taken every five minutes; from that time every ten minutes till 6.30 P.M. At 9 P.M. the glass shade was removed; and at 9.50 P.M. the last observation was taken.

Plate III. February 26.

The acid troughs having been left with the instrument under the shade the whole of the previous night, observations were taken at 8.30, 9, 9.10, and 9.25 A.M., showing an extremely dry state of the enclosed air. The shade was then taken off, and all the acid troughs removed, except one; shade replaced till 10.30 A.M., when it was removed for two hours.

At 12.30 the whole of the interior of the shade was completely covered with water in a fine state of division by use of a "spray apparatus," and placed over the instrument, the temperature of the room and instrument being raised, as in the previous experiment. At 2.15 P.M. this process was repeated, and again at 6.15 P.M. By 6.30 P.M. the mercury in the acid thermometer had gone out of range, having given a reading as high as 74° of excess over the dry bulb. At 6.40 P.M. the stove-fire was extinguished and the room cooled down gradually.

From 10.30 A.M. till 8 P.M., observations were taken at five-minute intervals.

Plate IV. February 29.

Observations taken every ten minutes from 10.20 A.M. to 5.20 P.M. (in doors) without the use of glass shade. At 5.20 P.M. the acid siphon was removed, and at 6 P.M. the acid-bulb thermometer had fallen to the same point as the dry bulb.

Plate V. March 19.

Observations taken out of doors under cover. At 12.30, all bulbs being dry, readings agreed. Water was now supplied to one and acid to another; by 1 P.M. the readings were:—wet 43°·7, dry 48°·8, acid 76°. At 6.30 P.M. the instrument was brought in doors.

ADDRESS

DELIVERED BY

THE PRESIDENT, J. W. TRIPE, M.D.,

AT THE

ANNIVERSARY MEETING, JUNE 19, 1872.

Gentlemen,—As this has been a year of great change in the Society, I [illegible] purpose adding one innovation more in delivering this Presidential Address [illegible] I think the time has now come when your President should at least once [illegible] during his two years of office address you at the Annual General Meeting [illegible] on some of the subjects connected with the Society, or the science for the [illegible] advancement of which we have gathered ourselves here to-day.

The chief reason why it has been deemed unnecessary for such an address to be delivered is the comprehensive character of the Report of the Council, which has hitherto included not only a statement of the progress of the Society, of the number of Fellows who have joined or resigned, and a brief biography of those who have died during the year, but has also referred to the advances made in Meteorology and in the improvement of meteorological instruments. The chief matter therefore of a President's Address being embodied in the Report, there was always a great risk of the address being merely an epitome of the Report, or else of little interest to the Society. I purpose being therefore very brief, and trust that what little I have to say will be deemed relevant to the chief objects for which we meet, viz. the well-being of the Society, and the advancement of the science which we all have more or less at heart.

For the reasons above stated I do not purpose referring to the progress which meteorology has made during the past year, except to congratulate you on the papers which have been read here; for, although less in number than in former years, they have been of great importance, and may lead to some permanent improvement in the means of recording facts. I shall now proceed at once to say a few words on the great changes which have been carried out by the Council since you did me the honour of election to the Chair. It has been felt for some time past that we have scarcely been keeping our position either with the public or with other societies, for the want of our own rooms, of a library which could be referred to [illegible]

all reasonable hours, and of some one who would attend in the Library daily, and carry out those troublesome but necessary duties on which the welfare of a Society so greatly depends. The income has been in some years but little more than the expenditure, so that it required considerable courage in the Council to carry out the measures which were deemed necessary.

As most of you are probably aware, we have for many years past had a room for our meetings, with coals and gas supplied to us without charge, through the liberality of the Council of the Institution of Civil Engineers. Last year, however, a question arose as to the liability of the Institution for rates if other societies were allowed to meet in their rooms; and notice was given to us, in a very kindly worded letter, of the position in which they felt themselves to be placed. Of course this Council could do nothing else than relieve the Institution of any liability which might arise out of our meetings; and, after much discussion and enquiry, we settled in these comfortable and suitable rooms. Having made this move, the Council determined to take a room temporarily in Great George Street, for the use of the Fellows as a Library, and also to appoint a paid Assistant Secretary. They have also elected an Editing Committee to superintend the publication of our Quarterly Journal (as our Proceedings are now termed), and assist in drawing up the Annual Report. The appointment of an Assistant Secretary has not been made from any want of confidence in the zeal and energy of the Secretaries who have hitherto performed these duties, but because it has been for some time evident that it was necessary to have some one who could give his whole time to, and throw all his energy into, the work of the Society. It is hoped that these arrangements will lead to greater prosperity, and also increase the status of the Society; but we shall, to a certain extent, be disappointed unless the Fellows at large afford that support which the Council trust they deserve. The additional cost entailed by these changes, which is very large when compared with the past income, renders it necessary for every one to use his best endeavours to increase our numbers, and so make the income sufficient to defray our present expenditure. I cannot conclude this part of my address without referring to the debt of gratitude which we owe to the Secretaries, and especially to Mr. Glaisher, for their past services.

I shall now very briefly allude to some facts connected with Meteorology and its correlations with sickness and death. In former times this word included the far more advanced science of Astronomy, but it is now restricted to a consideration of the ever varying states of the temperature, moisture, motion, and electricity of the atmosphere, which are included under the heads of climate, seasons, and the weather. The constant changes in the atmosphere arising from the division of the earth into land and sea, from the heating of the air by day, and the cooling of it at night, from the unevenness of the earth's surface, the permanent heat at the equator, and the cold of the polar regions, render the science of Meteorology dependent almost entirely on a large number of daily records taken at the same hour in different parts of the earth. Now as, until

quite lately, the instruments used by observers were not compared, it is quite evident that we must not have recourse to old observations, and therefore it has been impossible for Meteorology to have advanced at an equal pace with Astronomy. The time, however, is, I trust, fast approaching when we shall be able, by the discussion of the great mass of records now being made, to determine the causes which more immediately produce those changes of the atmosphere which we term "the weather."

It is true that for ages past most individuals have studied atmospheric changes to enable them, as far as possible, to forecast the weather; but even now no rules can be laid down by which we can tell the changes which will occur during any two or three consecutive days; and it is the hope of speedily being able to do this which induces farmers and the public generally to make some kind of observations in a rough way. I think it very necessary to keep alive this feeling, as by exciting a little additional interest in this matter many persons may be induced to procure good instruments and keep a daily record, who otherwise would be inclined to say, *cui bono*, and ignore meteorology altogether. I feel that while it is absolutely necessary that we should encourage the reading and publication of scientific papers, yet that we should also invite discussion and a free expression of opinion at our Meetings, so as to make those present feel that they are in the temperate regions rather than in the arctic circle of science. Indeed, I feel bound to confess that, during my earliest attendances, I often felt, after a long paper had been read, and then another, without any or but little discussion to relieve the tension of mind, that my mental faculties had become quite benumbed during the process.

The careful daily record of meteorological observations made with standard instruments was commenced at many stations some time before the compilation of Mortality Returns, in the office of the Registrar-General of Births and Deaths, so that the mortality tables of the Metropolis can safely be compared with the Greenwich returns, and for extra-metropolitan localities with those supplied by any of our observers. I carefully compared the Greenwich observations for some years with those made by myself at Hackney, by Mr. Burge at Fulham, Mr. Symons at Camden Town, and Mr. Heywood in the City, and ascertained that the mean daily temperature did not vary on an average more than half a degree, although the maximum and minimum observations differed very considerably. I have therefore used the Greenwich Tables in all my comparisons between the rate of death from different diseases and varying states of the weather. A number of valuable results have already been obtained as regards the course of epidemics, the influence of high and low temperatures on the public health, and, to a less extent, of different hygrometric conditions of the air. Dr. Hoskins, one of our Fellows, long since (about 1855) wrote a valuable paper on the "Correlation between Meteorological, Medical, and Agricultural Science;" and I commenced a series of essays in 1848 on the influence of variations in the temperature, moisture, weight, and electricity of the atmosphere, on the death-rates of scarlet fever, and other epidemic diseases. The Manchester Medical Association, Dr. Ballard, and others have written

on the effects of variations of temperature on the health of the people. The whole of the writers have arrived at tolerably uniform conclusions, viz. that very cold and very hot weather induce an increase in the number of cases of disease and of deaths, and that a temperature between 55° and 65° is most beneficial to health in this country. I stated many years since, in one of my reports, that a cold wet summer always coincides with a less amount of sickness and fewer deaths than a hot dry summer.

It is somewhat singular that whilst very cold weather causes a great increase in the sickness and mortality of any given population, and especially amongst the very young and very old, the increase should extend to almost all diseases. It is true that the chief sickness and mortality are caused by affections of the lungs; but there is also a greater number of cases, although not of deaths, even from diarrhœa. Thus the rate of death, in weeks having a mean temperature of less than 35°, was nearly 45 per cent. greater than in weeks having a temperature of 60°–65°; and in weeks having a mean temperature above 65° the average rate of death was about 30 per cent. more than in weeks having a mean ranging between 60° and 65°. The range of temperature in this country which is the best for health is so small that every one should use reasonable care when the mean is above or below the standard; at the same time we must not forget that extremes are always injurious, whatever the average may be. This is especially the case as regards diarrhœa; for the mortality from this cause, with a continuance of the mean above 65°, is at least twenty times as great as at 40°–45°. The comparison between temperature and epidemic diseases has led to the important facts that, as regards smallpox, it produces the smallest number of deaths as soon as the daily mean reaches 62°, and has continued a short time at that degree of heat, which is usually about the end of July or early in August, and does not become so fatal again until the mean temperature has sunk for a short time below 54°, which is generally about the end of September. This is not quite invariable, as it varies somewhat in epidemic and non-epidemic years. The fatality from smallpox increases as the temperature sinks below 54°, until the middle of January, when the lowest average temperature is ordinarily reached, viz. about 35°·5. Scarlet fever, on the other hand, is at its lowest point from the middle of March to the end of the third week in April, when the daily mean varies between 41°·5 and 47°·5, from which it gradually increases in fatality as the weather gets warmer, but not quite at an equal ratio until the end of October or early in November, when the impetus apparently given to it by the warm weather has ceased, and the mortality declines. I have very carefully examined the influence of other meteorological elements on the disease, and find all of them to be almost inert as compared with that of temperature.

How far the temperature, moisture, and electricity of the atmosphere are concerned in exciting diseases to become epidemic, we are unable at present to state; but the periodicity which epidemics exhibit are opposed to these being the chief causes. Thus, smallpox, scarlet fever, and measles have a very decided tendency to become epidemic in the Metropolis every fourth year, whilst there is no single meteorological element or combination

of elements which has so decided a periodical excess or minus of its average amount. A record of correct observations extending over many more years than we now possess, and a close comparison of these with correct returns of sickness and death in any sufficiently large area, will, I do not doubt, enable statisticians to determine the precise relations which exist between the state of the public health and meteorology. There is at present, however, so little known of the varying electrical conditions of the air (at least so as to measure the changes), that I am perhaps somewhat premature in expressing this opinion.

In conclusion, I cannot but express my conviction that at the termination of my second year of office, the Council will be able to make a satisfactory report as to the number of Fellows, the scientific character of the Papers, and the financial position of the Society.

REPORT OF THE COUNCIL,

READ AT THE ANNIVERSARY MEETING, JUNE 19, 1872.

At the close of this the 22nd Session of the Society, and the 6th since its incorporation, the Council have to report to the Fellows a period of some scientific activity, which they think affords promise of increasing usefulness and renewed prosperity.

It will be in the recollection of the Fellows that, at the last Anniversary Meeting, a Resolution to the following effect was adopted, namely:—

> "That it be referred to the Council to consider whether or not it be possible to improve the position of the Society with reference to the Government and the Public generally, and in especial relation to the 'Aid to Science' Commission now sitting."

This Resolution has since been the subject of careful deliberation, and the general tenor of this Report will show that the Council has already been able to take some practical action towards the accomplishment of the objects therein contemplated.

A reference to the following figures, which give the numerical strength of the Society at the close of every Session since 1861, will show at a glance that the Society has not increased as steadily as could have been desired during the last seven years:—

1862. 241.	1865. Not given.	1868. 329.	1871. 340.
1863. 282.	1866. 329.	1869. 330.	1872. 314.
1864. 300.	1867. 331.	1870. 341.	

The Council have therefore felt, in the face of these figures, that it was expedient to introduce some change which may increase the claims of the Society to a larger measure of public recognition.

In the first instance it has appeared to them that, in regard of the Re-

ports on the Meteorology of England, issued quarterly by the Registrar-General, that it would be an advantage and convenience if they could be bound up with the 'Proceedings,' and it was therefore determined, at the close of the fifth volume of the 'Proceedings,' to commence a new series, in Royal 8vo, to appear at intervals of three months, under the title of the "Quarterly Journal of the Meteorological Society," and of which the first Number was that for January 1872. Mr. Glaisher, who had been for several years Editor of the 'Proceedings,' having expressed a wish to be relieved from this labour, the Council have delegated the duty to a Sub-committee consisting of three members of their body, thus returning to a former practice of the Society. They cannot, however, allow this change to occur without placing on record their sense of the great services rendered by Mr. Glaisher to the Society in his capacity of Editor.

The sum of £52 per annum, allowed by Resolution of Council, dated June 21, 1865, "towards the expenses of editing the Proceedings, issuing notices and circulars, and the general work of the Society," has been rendered available for other uses by the new arrangement.

The first matter, as regards the accommodation of the Society to which the notice of the Council was drawn, was the necessity of providing a place for the Meetings. Early in the autumn the Council of the Institution of Civil Engineers notified to your Council that they would probably find it necessary to request the Society to seek apartments elsewhere, as they were unable to afford it the same facilities for its Meetings as heretofore.

The Council, on receipt of this notification, at once took steps to procure other suitable rooms. An offer of temporary accommodation in the Meteorological Office, free of charge, was made by the Director of that office with the sanction of the Meteorological Committee. It appeared, however, on the whole, best temporarily to act on a proposal made by one of the Secretaries, Mr. Brooke, on behalf of the Victoria Institute, and to make arrangements for the Meetings to be held during the Session in their rooms, a small sum being paid for the accommodation.

The Council are very glad, however, to say that they have lately received an intimation from the Institution of Civil Engineers, to the effect that there is no longer any objection to the return of the Society to the rooms in which it has met for so many years, and accordingly, with the warmest expressions of gratitude for the hospitality now tendered afresh, the proposal has been accepted, and next Session the Society will again meet at No. 25 Great George Street.

The Council have also much satisfaction in stating that they have at length found it possible to carry into execution an arrangement foreshadowed ten years ago in the Annual Report for 1862, in the following words:—

"Of course the Council cannot fail to look forward to the time when we shall have offices of our own, where Members will find the books and MSS. of the Society, and an officer of the Society in charge, so that facilities may be offered to Members which are to a certain extent impracticable at present."

A Subcommittee was, in the first instance, appointed to seek for a room conveniently situated and suitable for an office. Some difficulty was experienced in securing the requisite accommodation at a reasonable rate, and at last it was decided to ask Mr. Beardmore, Vice-President, who has for the last eleven years most kindly housed the library free of charge, whether he would allow the Society, under the circumstances, to become, for a time, tenants of the room in which the books are stored, at a small rent. The proposal was at once acceded to, and a rent of £20 per annum named, an offer which the Council thankfully accepted. They entered into possession of the room, situated at No. 30 Great George Street, Westminster, on the 1st of May, and they hope that, from its proximity to the apartments where the Meetings will be held during the ensuing Session, it will be found convenient for the Fellows at large.

The next step was to make arrangements for the attendance in the room of "an officer in charge," and at the Meeting in February a scheme of duties for such an officer was entered on the Minutes.

At the Meeting in April Mr. W. Marriott, previously engaged at Greenwich Observatory as a supernumerary computer in the Magnetical and Meteorological Department, was appointed Assistant-Secretary, and this gentleman commenced his duties as such on the 1st of May, being in attendance daily from 11 to 5, except on Saturdays, when the office closes at 2 P.M.

The task of prescribing to him his sphere of operations was entrusted to the Library Committee, which has been appointed at the request of the Hon. Librarian. The most pressing matter to which the attention of the Assistant-Secretary could in the first instance be turned was, without doubt, the reorganization of the Library, inasmuch as our Librarian, despite his exertions, had been unable to get it into order. Accordingly steps have been taken to complete the binding of the volumes, to provide additional shelf-accomodation, and to arrange the books. The funds necessary for this work have been obtained by the sale of a number of duplicate and non-meteorological works which have from time to time accumulated.

The most important part of the duties of the Assistant-Secretary will, however, be the examination and discussion of the materials furnished to the Society by its observing Fellows, and the Council hope ere long to have good material for this work.

It is proposed to publish in future numbers of the 'Journal,' short notices of the discussions which take place at the Meetings of the Society, and abstracts of papers which the Council do not print in full in the 'Journal.'

The Editing-Committee propose to return to an earlier practice of the Society, and insert regularly, as well as correspondence, notices of recent meteorological works and of the progress of the science generally. These notices, however, will necessarily be simple abstracts, without the expression of any opinion as to the views of the authors.

It is hoped that by the adoption of these measures the Journal will become a means of keeping the Fellows of the Society acquainted with

the progress of meteorology both at home and abroad, and at the same time that it will be rendered more interesting to the general public.

It has been resolved to issue henceforth by post to the Fellows, prior to each Meeting, timely notice of the papers to be read at the Meeting.

The Council have not as yet taken any steps to bring the Society under the notice of the "Aid to Science Commission" now sitting, under the Presidency of the Duke of Devonshire.

The following is a Tabular Statement of the present numerical strength of the Society:—

	Fellows.			Totals.
	Life.	Ordinary.	Honorary.	
1871, June 21	73	259	8	340
Since elected	+1	+ 2	...	+ 3
Since compounded ...	+1	− 1	...	0
Deceased	...	− 7	...	− 7
Retired	...	− 4	...	− 4
Defaulters	...	−18	...	−18
1872, June	75	231	8	314

An abstract of receipts and expenditure for the year ending December 1871 is given in Appendix II., from which it will be seen that the balance in favour of the Society on current account at that date was £161 11*s.* 9*d.* Finding at the commencement of the financial year that there was an accumulation of arrears of subscriptions, the Council caused special appeals to be made to the defaulters for payment. This led to some of the claims being settled; but in many instances the applications met with no reply, and the Council felt it to be their duty to remove from the list of Fellows the names of eighteen gentlemen who had allowed their subscriptions to remain in arrear, and from whom repeated application failed to elicit a response. The outstanding subscriptions for 1871 and previous years now amount to £105, due from forty-three Fellows.

The ordinary income and expenditure of the Society in the last ten years, exclusive of expenditure on Capital Account, has been:—

Year ending	Income. £	*s.*	*d.*		Expenditure. £	*s.*	*d.*
1862	282	11	8	......	223	4	10
1863	335	15	1	......	197	10	6
1864	528	10	1	......	321	17	4
1865	249	7	6	......	271	17	6
1866	275	4	10	......	273	14	8
1867	318	6	9	......	213	5	7
1868	271	19	6	......	258	10	11
1869	239	4	4	......	228	19	9
1870	321	16	8	......	244	19	2
1871	244	3	9	......	197	2	10

In the same period, the sum of £547 7*s*. 9*d*. has been invested in £600 New 3 per Cents on Capital Account, which has been augmented since the commencement of the current year by the purchase of £100 of the same stock for £91 7*s*. 6*d*. The total capital of the Society consists of £1100 New 3 per Cents, invested in the joint names of the Trustees, Sir Antonio Brady, S. W. Silver, and H. Perigal, the Treasurer. The cost has been £1007 17*s*. 7*d*., and the value at the current quotation, 92, is £1012.

The Council regret to have to announce the recent death of the Collector, Mr. F. C. Fisher. The Treasurer has, for the present, authorized the late Mr. Fisher's partner, Mr. Charles W. Stidstone, to continue to receive the subscriptions of the Fellows.

The Society has to deplore the loss of seven of its Fellows by death; their names are:—

Henry Barrow, F.R.A.S., elected into the Society May 1850.

Jasper Bolton, elected November 1869.

F. W. Doggett, elected November 1854.

John Freeland, elected February 1871.

D. A. Freeman, F.R.A.S., elected November 1864.

Capt. James Aulaby Legard, R.N., K.T.S., elected May 1851.

John Pike Stephens, elected June 1864.

Mr. F. W. Doggett had belonged to the Society for nearly eighteen years, and served on the Council from May 1856 to June 1861, and again from June 1866 to the time of his decease. Several contributions from his pen appear in the early Reports, and latterly in the 'Proceedings.'

In 1855 he contributed a paper "Upon the Weather in connexion with *Aphis*-blight and Growth of Hops," in which he endeavoured to show that those years which had been visited by a great excess in the fall of rain in the quarter ending September, previous to the growth of the crop, with a comparatively dry succeeding quarter ending December, and month of March, the attack of *Aphis*-blight had proved fatal to the plant in a greater or less degree. It also appeared that when the rain in the quarter ending September of the previous year was in defect, an average or large crop was secure, and that nearly all the small crops were grown in years in which the temperature of the summer was below the average, whilst the large crops were produced in warm summers.

In another paper, presented in the same year, upon "The Weather in connexion with the Crop of Barley," it was shown that a generally warm period of fifteen months before the harvest-time would mostly produce a large crop; and that, on the contrary, when the like period was cold, short crops had resulted.

In the following year Mr. Doggett contributed a paper "On the Weather in connexion with the Wheat-crop," in which he observes that, "in those years which have produced the *largest and best crops*, the temperature for

the *twelve* months preceding each harvest has been generally much *above the average*; . . . . . whilst, on the contrary, the years which have been *generally cold* have produced crops which are noticed particularly as having been bad in quality." He goes on to state that "the fall of rain does not appear to have exercised so much influence upon the crop as might have been expected, as in both of the above series there have been both wet and dry years; and that the period just before sowing the seed has been both *wet and dry* previous to the large and small crops. Should the fall of rain, however, be much in excess in the summer, when the corn is forming in the ear or ripening, the result appears to be deplorable."

In January 1869 he read a paper on "The Weather in connexion with the Crop of Hops of the Year 1868." In this, after having stated that it was generally expected that the unusually fine weather of the previous spring and summer would produce one of the most abundant as well as the best crops of hops ever known, he says that at the end of June he observed on the hop-plants a new description of *Aphis*, rather larger than that hitherto known as the hop-fly, and with the colour of its body somewhat darker. In the course of about three weeks the leaves of the plant began to show the effects of the blight, changed colour from green to brown, and eventually dropped off, the blossom withering at the same time. Rain did not appear to benefit the plants; for two or three days after a fall the hops were found to be in a much worse condition. He believed that the absence of thunder and lightning about the time that the flower is being perfected is prejudicial, and favours the growth of mould; and that a reference to those years in which the disease had been very fatal, and to those in which the crop was large and healthy confirmed this view.

In June 1869 he contributed two short papers, entitled "Weather-signs as to Temperature" and "Weather-signs as to Rain."

The following Papers were read at the Ordinary Meetings during the Session 1871–72:—

NOVEMBER 15, 1871.

1. "On the Direction of the Wind at the Royal Observatory, Greenwich, in the Ten Years ending December 1870." By James Glaisher, F.R.S.

2. "Observations of the August Meteors in 1871." By Professor Alexander S. Herschel, F.R.A.S.

3. "On the Electric Cumulus." By S. Barber, F.M.S.

4. "Notes upon the Aurora Borealis of 1871, November 10." By W. C. Nash, F.M.S.

JANUARY 17, 1872.

5. "On Large and Small Anemometers." By the Rev. Fenwick W. Stow, M.A., F.M.S.

6. "On Deep-Sea Thermometers prepared under Admiral FitzRoy's superintendence." By Robert H. Scott, M.A., F.R.S.

FEBRUARY 21, 1872.

7. "On Bourdon's Metallic Barometer." By the Rev. E. Hill, M.A

8. "On the New Form of Cloud described by M. Poey in 'Nature' October 19th, 1871." By R. H. Scott, M.A., F.R.S.

MARCH 20, 1872.

9. "On the Thunder-storms reported to the Meteorological Office dur the Six Years 1866–71." By Robert H. Scott, M.A., F.R.S.

10. "On a New Hygrometer." By E. O. Wildman Whitehou F.M.S.

APRIL 17, 1872.

11. "On the Temperature of Hill and Valley." By George Din F.M.S.

12. "On Certain Defects in Anemometric Registration." By C. O. Cator, M.A., F.M.S.

The list of Officers and Council for the ensuing year forms Appendi
The Treasurer's Balance-sheet will be found in Appendix II.

The Council, in accordance with their usual practice, append to Report notices of the proceedings of several establishments and obser tories, for which they are indebted to the kindness of the gentlemen spectively in charge. The portion relating to Greenwich Observatory been extracted from the Report of the Astronomer Royal to the Board Visitors, presented on the 1st instant. These notices form Appendix I

Appendix IV. contains a list of the Books &c. received for the Libr during the past year.

APPENDIX I.

LIST OF OFFICERS AND COUNCIL, elected June 19, 1872.

President.

JOHN W. TRIPE, M.D.

Vice-Presidents.

ARTHUR BREWIN, F.R.A.S.
ROBERT H. SCOTT, M.A., F.R.S.
GEORGE JAMES SYMONS.
CHARLES VINCENT WALKER, F.R.S.

Treasurer.

HENRY PERIGAL, F.R.A.S.

Trustees.

SIR ANTONIO BRADY, F.G.S.
STEPHEN WILLIAM SILVER.

Secretaries.

CHARLES BROOKE, M.A., F.R.S., F.R.C.S.
JAMES GLAISHER, F.R.S.

Foreign Secretary.

LIEUT.-COL. ALEXANDER STRANGE, F.R.S.

Council.

CHARLES O. F. CATOR, M.A.
GEORGE DINES.
HENRY STORKS EATON, M.A.
ROGERS FIELD, B.A., Assoc. Inst. C.E.
FREDERIC GASTER.
ROBERT JAMES MANN, M.D., F.R.A.S.
WILLIAM CARPENTER NASH.
THOMAS SOPWITH, M.A., F.R.S., M. Inst. C.E.
REV. FENWICK W. STOW, M.A.
CAPT. HENRY TOYNBEE, F.R.A.S.
SAMUEL C. WHITBREAD, F.R.S.
E. O. WILDMAN WHITEHOUSE, Assoc. Inst. C.E.

APPEN

Abstract of Receipts and Expenditur

Receipts.

1871.		£ s. d.	£ s. d.	£ s. d.	£ s.
Jan. 1.	To Balance		......		114 10 1
April.	Dividend on £1000 New 3 per Cents		14 15 0		
Oct.	Do. do. do.		14 12 6		
	Dividends		29 7 6		
	Subscriptions for 1866	1 0 0			
	Do. for 1867	1 0 0			
	Do. for 1868	4 0 0			
	Do. for 1869	10 0 0			
	Do. for 1870	17 10 0			
	Do. for 1871	155 3 0			
	Do. for 1872	3 0 0			
	Do. for 1873	1 0 0			
	Do. for 1874	1 0 0			
	Do. for 1875	1 0 0			
	Subscriptions	194 13 0			
	Fr. Nunes, Esq., Composition	10 0 0			
			204 13 0		
			234 0 6		
June 30.	Sales of Proceedings, &c.	7 4 6			
Dec. 31.	Do. do.	2 18 9			
	Sales		10 3 3		
	Receipts				244 3
					£358 14

DIX II.

for the Year ending December 31st, 1871.

Expenditure.

1871.					£	s.	d.	£	s.	d.
Jan. 18.	By Printing Proceedings, No. 52				16	7	9			
Feb. 15.	Do. do. No. 53				11	12	6			
Mar. 15.	Do. do. No. 54				11	9	10			
April 19.	Do. do. No. 55				34	1	9			
June 21.	Do. do. No. 56				18	5	5			
	Proceedings, Five Nos.							91	17	3
Feb. 17.	Do. Charter, Bye-Laws, &c.				4	15	0			
Dec. 31.	Do. Sundries				3	13	5			
	Do. Registrar-General's Reports				5	12	0			
								14	0	5
	Printing							105	17	8
	Stationery	6	2	6	15	2	6			
	Postage Stamps	9	0	0						
	Secretary's Petty Expenses	3	17	0	6	5	2			
	Librarian's Do.	2	8	2						
	Attendance, Refreshments, &c.				7	8	0			
	Expenses							28	15	8
	Deed-Box for Dies, &c.							0	15	0
	Editor of Proceedings				52	0	0			
	Collector's Percentage				9	14	6			
	Salaries							61	14	6
	Payments							197	2	10
	Balance							161	11	9
								£358	14	7

HENRY PERIGAL, *Treasurer.*

Examined with the Vouchers, and found correct, 7 June, 1872. } W. C. NASH, *Auditor.*

APPENDIX III.

THE METEOROLOGICAL OFFICE. Robert H. Scott, M.A., F.R.S., Director.—The work done at this Office during the year will be considered under the same heads as were given in the last Report of the Society.

1. *Ocean Meteorology.*—At the close of the year 1871, 97 ships, furnished with standard instruments by the office, were at sea in various parts of the ocean, and the total number of ships' registers &c. received since the establishment of the Meteorological Department of the Board of Trade had amounted to 2844.

The extraction of the information relating to the Equatorial portion of the Atlantic Ocean, which was contained in this store of documents was completed at the end of the year, and its discussion has been commenced. The portion first taken in hand has been the district lying between the Equator and Lat. 10° N. and between the Meridians of 20° and 30° W., a region traversed by almost every ship that crosses the Equator in the Atlantic. The Committee intend to issue a few copies of a chart of this district for the month of January, in order to elicit opinions as to their proposed method of publication of results.

The publications which have appeared during the year, in connexion with this branch of the office, have been two in number*, both of them being the completions of work first undertaken by direction of the late Admiral FitzRoy. As regards the first of these publications, it may be said that, although many parts of the charts suffer materially from want of data, there is such a general agreement amongst them that a cursory inspection of the isobars, isotherms, and wind-arrows gives a good idea of the relation between Pressure, Temperature, and Wind. The way in which an area of high pressure exists over the sea somewhere between 22° and 42° S., but does not extend to the land, is remarkable. In connexion with this area of high pressure it is an interesting fact that the temperature is considerably higher over the district where it is observed than it is near the coast. It seems probable that the cool temperature of the coast is brought about by the prevalent southerly winds. The charts show that where the isobars are closest the winds are strongest, and where they diverge from each other light breezes are usually reported. Patches of high pressure seem to be frequently accompanied by light airs and calms. An irregular course of the isobars is generally indicative of atmospheric disturbance or of variable winds. As illustrative of the climate of South America, additional data is given for pressure, temperature, winds, and rainfall for Punta Arenas, Puerto Montt, Valdivia, Valparaiso, Santiago, Copiapo, and Coquimbo. The second of these investigations, that relating to the Atlantic currents, has been carried out almost entirely by Mr. Richard Strachan. It deserves especial notice, as it has involved very troublesome calculations. The charts are the only monthly current-charts, and the only charts for such small areas ($2\frac{1}{2}$-degree squares) which have ever appeared. An annual chart is given, showing the mean current for the year in each square.

A most interesting investigation has been undertaken by Capt. Toynbee with reference to the weather over the Atlantic during the end of January and beginning of February 1870, the time when the 'City of Boston' was lost. It will be remembered that the south-east gales of the 5th and 6th of February did a great deal of damage on our own coasts, especially at Wick.

2. *Telegraphy and Weather-warnings.*—The system remains much in the same condition as in former years: a new station has been established at Dunrossness near Sumburgh Head, in the Shetland Islands.

In addition, observations from Fanö, in Denmark, and from Cuxhaven, have been added to the regular list of reports published in the Daily Weather Report.

The Office commenced, on the 11th of March, the publication of Daily Weather-Charts, of which a copy is regularly sent to the Society; they differ materially from those which are given in the Bulletin International of the Paris Observatory and those prepared by the Signal Office, Washington. The charts in question are four small ones, respectively exhibiting for each day the conditions of—1. Pressure. 2. Temperature. 3. Wind- and Sea-disturbance. 4. State of the Sky and Rain; so that the state of the weather over these Islands and the north and west coasts of Europe can be seen at a glance. The idea of employing four small charts instead of one large one, is entirely due to a former Fellow of the Society, Mr. Francis

* Contributions to our Knowledge of the Meteorology of Cape Horn and the West Coast of South America. Stanford, 1871. Price 2*s.* 6*d.*

Currents and Surface-Temperature of the North-Atlantic Ocean, from the Equator to 40° N. Stanford, 1872. Price 2*s.* 6*d.*

Galton, F.R.S. It is unnecessary to enlarge further on this matter, unless to state that the cost of subscription is £1 per annum for delivery by book-post, and £2 per annum for delivery by hand in London. The charts are furnished free of charge to the Government Offices and to any observatories or private observers throughout the country who supply observations to the Meteorological Office.

The only change as regards the issue of telegraphic intelligence of storms, is that the drum is now kept up for 48 hours instead of 36, and in every case when the danger seems to be past before the 48 hours have expired, an order is issued to lower the drum.

The supply of fishery barometers to small fishing-stations on our coast has been continued.

3. *Land Meteorology of the British Islands.*—This work goes on steadily, the seven observatories are all in complete working order. The Quarterly Weather Report for the year 1870 has appeared, and it contains, in addition to the plates of the instrumental records and the explanatory chronicle of the weather, tables of the mean barometrical readings, and of the rainfall at several of the telegraphic reporting stations, and a translation of Bessel's paper "On the Determination of the Law of a Periodical Phenomenon," from the 'Astronomische Nachrichten,' No. 136, which now, for the first time, appears in full in English. It need hardly be mentioned to the Society that Bessel's formula, which is given in this paper, has been almost universally employed on the Continent for many years for the expression of the march of meteorological phenomena. It has been used in the discussion of the thermometrical observations for Toronto, published in 1853 by Sir E. Sabine, and has also been employed for many years at the Radcliffe Observatory, Oxford.

The only other matter connected with the office which calls for remark is that Mr. Galton has invented a Trace computer which was made by Messrs. Beck, of Cornhill, and was exhibited at the last soirée of the Royal Society. This instrument, which at present is set to work on one special class of deductions, is applicable to many others. It may be made to perform all statistical calculations where the desired result is a *function of two independent variables,* and where both the data and the results are *graphically represented.*

It is now employed in deducing and dotting out a trace of the values of the vapour-tension from the corresponding traces of the dry- and wet-bulb thermometers. The abscissa of any point, in each of the three traces, represents the time to which that point refers; and the ordinates which lie in the same vertical line represent, respectively, the simultaneous heights of the two thermometers and the instrumentally deduced amount of vapour-tension.

The discussion of the anemometrical returns from Sandwick Manse, in the Orkney Islands, where an anemometer was erected by the late Admiral Fitz-Roy at the end of 1862, has been entrusted to Mr. James S. Harding, and the results for the six years, 1863–8, are complete, and are in the press, as an Appendix to the Quarterly Weather Report for 1871. The discussion has been carried out on the plan suggested by the Rev. T. Romney Robinson, D.D., F.R.S., of Armagh, the inventer of the anemometer.

ROYAL OBSERVATORY, GREENWICH. Sir G. B. Airy, K.C.B., P.R.S., Astronomer Royal.—The meteorological instruments are all in a good state. The action of Robinson's anemometer was rather unsatisfactory; some parts of it have been replaced. In the register given by Osler's anemometer there has been a suspicion (it cannot be said whether well founded) that in stormy weather the records of high pressure have been unjustly great, in consequence of the inertia of the weight which pulls the pressure-string, and the inertia of the weight with which the pencil was loaded; both are now replaced by springs. All the other instruments (barometers, thermometers with dry bulb and wet bulb, pluviometers, deep-sunk thermometers, and thermometers plunged in the Thames) are in good order. Means have been arranged for easily lighting the gas-burner which warms the insulating glass pillar, so that few electrical indications are lost from the failure of the lamp; but the electrical apparatus is not satisfactory.

The public barometer, fixed in the outside wall of the Observatory inclosure, and exhibiting the principal barometric fluctuations on a large scale, is in good order.

Every class of instruments has been kept in constant action; the photographic, the eye-observing (principally used as giving zeros for the photographic), the maximum and minimum, and the instruments for accumulation.

The great aurora of 1872, February 4, was well observed. On this occasion the

term borealis would have been a misnomer; for the phenomenon began in the south, and was most conspicuous in the south. Three times in the evening it exhibited that umbrella-like appearance which has been called (perhaps inaccurately) a corona. Brilliant displays of aurora were seen in many parts of the world, and in equatorial and southern latitudes, on the same evening and about the same time.

As regards the meteorological results: the eye-observations are corrected for recognized errors of the instruments, and the dew-point and degree of moisture are computed to the present time; and time-scales and new base-lines are laid down, where required, to the end of 1871. The anemometers and the photographic thermometers require no base-lines, and the anemometers require no new time-scales.

The vane of Osler's anemometer revolved in the year 1871 through —2·4 complete rotations.

I have very carefully compared the momentary phenomena of the aurora of 1872, February 4, with the corresponding movements of the magnetometers. In some of the most critical times the comparison fails on account of the violent movements and consequent faint traces of the magnetometers. I have not been able to connect the phases of aurora and those of magnetic disturbance very distinctly. Preceding comparisons had led me to expect that the umbrella-shaped corona would be accompanied with a very violent disturbance of vertical force, but I can hardly say that the expectation was borne out in the three coronæ of the evening of February 4. I intend to repeat these comparisons in a different way at the next aurora which we may be privileged to witness.

The reductions of the photographic records of thermometers from 1848 to 1868 have been advancing. The diurnal laws of the dry-bulb thermometer, as depending on the month, on the temperature-waves, and on the barometric waves, have been taken for the whole period; the two former have been examined through twelve years, and the last through three years. The similar computations for the wet-bulb thermometer are commenced.

I could wish to receive powers for making a similar investigation of the diurnal laws of temperature as referred to the prevalence of different winds; with that I think that the examination of temperatures from 1848 to 1868 may appropriately close.

The magnetical and meteorological work of 1870 is entirely printed.

The meteorological section contains, in monthly arrangement, various particulars and results of daily barometric and thermometric readings, temperature of the Thames water, winds, electricity, clouds and weather. These are followed by tables of various monthly means, barometric waves, daily readings of deep-sunk thermometers and their means, change of direction of wind through each month and through the year, rainfall, and luminous meteors.

KEW OBSERVATORY. Samuel Jeffery, Esq., Superintendent.—The management of the Observatory has undergone very serious changes during the past year. The British Association, having carried into effect their announced intention to discontinue the Annual Grant of £600 towards the expenses of the establishment, Mr. Gassiot, the former Chairman of the Kew Committee of the British Association, most munificently made a proposal to hand over to the Royal Society the sum of £10,000 on the condition that magnetical observations should be kept up at Kew as heretofore. This offer was accepted by the President and Council of the Royal Society in the month of June, and the Members of the Meteorological Committee were nominated to superintend the Observatory under the title of the "Kew Committee of the Royal Society." Mr. Jeffery was appointed Superintendent, and entered on his duties in August.

There has been no variation from the course of duties pursued during late years. The autographic records, both magnetical and meteorological, have been continued without interruption, and the Returns for the latter forwarded to Kew (as the central) for examination, have been regularly sent from the several outlying Observatories supported by the Meteorological Committee.

An Anemometer of the Kew pattern, having a new arrangement for recording velocity, has been erected, and is now on trial.

The customary work of testing Barometers, Thermometers, &c., continues to be done, and the number which have been verified are as follows:—

Barometers:—Aneroid, 18; Mercurial, 68. Thermometers, 1706 (including 893 clinical). Hydrometers, 12 (marine). Sextants, 4. Anemometers, 4. Rain-gauge, 1; and Evaporating-dish, 1.

There have also been verified for Owens College, Manchester, a Standard yard, and a Cathetometer Scale, and 12 Standard Thermometers have been constructed at Kew.

Royal Observatory, Edinburgh. Prof. C. Piazzi Smyth, F.R.S.—Without interfering with the current observations of earth-thermometers, or the extensive monthly computations for the Registrar-General of Scotland of the returns from fifty-five Scottish stations,—the last year has been eminently one of making up the Observatory books in Meteorology as well as Astronomy, the results of which will be seen in the xiii.th volume of 'Edinburgh Observations,' recently issued. In Meteorology we may notice:—(1) the bearing on future years of the last thirty-three years of earth-thermometer observations; (2) the condensed representations of seven millions of observations by the Scottish Meteorological Society as computed at the Royal Observatory, Edinburgh, during the last fifteen years; and (3) the history and discussion of that most notable of northern storms, which occurred in October 1860, and has been traced from Greenland in the West to Siberia in the East, but had its chief intensity when crossing the west coast of Scotland.

There are likewise some spectroscopic observations on the aurora, twilight, and zodiacal light, which may ultimately prove of importance.

Radcliffe Observatory, Oxford. Rev. R. Main, M.A., F.R.S.—The uniformity with which the meteorological observations at this Observatory are made and reduced from year to year, prevents the necessity of a lengthened report. All the instruments referred to in former reports have been kept in use, and there have been no accidents causing interruptions in the continuity of the photographic records worthy of being specifically mentioned.

The observations for 1869 have been reduced in the usual way, and the only fact worth mentioning is the still westerly progress of the resultant direction of the wind, which was, in 1869 S. 80° W., while in 1868 it was S. 38° W. The forward direction is longer than might have been anticipated, and the results for the next two years may be looked forward to with considerable interest. For the numbers in correspondence with the whole sun-spot cycle, the preceding Annual Report of the 'Proceedings of the Meteorological Society' may be consulted.

For several years past the observations have been communicated weekly to two local papers, 'The Oxford Chronicle' and 'The Oxford Journal,' and it is to be regretted that the editors of both those papers have found it necessary, on the ground of inconvenience, to discontinue the publication of them, their utility admitting of no question.

The Fellows of the Society will probably hear with satisfaction that in future Oxford is to be one of the new inland stations from which observations are to be sent by telegraph to the Government Meteorological Office.

Cambridge Observatory. Prof. J. C. Adams, M.A., F.R.S.—The meteorological work at this Observatory for the past year consisted of the daily readings at 9h A.M. and 3h P.M. of the barometer, dry- and wet-bulb thermometers, anemometer, and rain-gauge.

The instruments having acted satisfactorily, no change has been made in them.

The observations are reduced daily, and a quarterly and yearly summary sent to the 'Cambridge Chronicle' and to Mr. Symons.

The College Observatory, Stonyhurst. Rev. S. J. Perry, S.J., M.A., F.R.A.S.—No change of importance has taken place this year either in the staff of the Observatory, or in the ordinary routine work.

The instruments supplied by the Meteorological Office having been in constant use for more than four years, it was thought advisable to compare their results with those obtained from the meteorological instruments read morning and evening during the last five-and-twenty years. The deduced monthly mean temperatures show a very slight excess of 0°·2 Fahr. in favour of the results from the two daily readings over the figures given by the photographic records.

The instruments to be read daily have been increased by the addition of a maximum thermometer of Negretti, and a mercurial minimum of Casella, which were provided by the Meteorological Committee in order to supply any possible loss of the maxima and minima of the photographic curves.

The displays of Aurora Borealis, so frequent during the past twelve months, have all been carefully observed, and every remarkable change in the phenomena noted. Since the beginning of January weekly observations of the magnetic declination have been taken instead of the monthly ones of former years. The photo-magnetic curves are being systematically measured with the view of investigating the connexions that may exist between the magnetic and meteorological phenomena. During the months of August and September a magnetic tour was made in Belgium with the Stonyhurst instruments. I was aided in this survey by Mr. W. Carlile, the magnetic assistant of the Observatory; and we were able to obtain complete sets of elements at Brussels, Alost, Antwerp, Arlon, Aix-la-Chapelle, Bruges, Courtrai, Ghent, Louvain, Liège, Mons, Namur, Ostende, Spa, Tournai, Tronchiennes, and Turnhout, besides observing the dip at Lierre, Mechlin, and Verviers.

A paper on the Magnetic Survey of the East of France, taken with the same instruments, is published this year in the 'Philosophical Transactions' of the Royal Society.

Norwich Meteorological Society.—The meteorological observations have been continued, and registered regularly during the past year. The monthly averages have been carefully obtained and forwarded to Mr. Glaisher as formerly. No new instruments have been added to the collection; but those belonging to the Society have worked very satisfactorily. The principal paper read during the year was one on the "Temperature of the Air at Norwich for the month of June," showing a mean temperature of 58°·85 for the 30 years ending 1870, the mean maximum temperature being 67°·4 and the mean night 50°·3.

British Rainfall Investigations.—The organization for the collection and publication of all reliable observations of rainfall made in the British Isles is in full operation, and gradually growing in uniformity and completeness. The observers have not only increased in number from two hundred to nearly two thousand; but the greatest care has been taken to obtain returns from thinly inhabited parts of the country, such as Dartmoor, the eastern Lake-District, Inverness, the Hebrides, the Orkneys, and the West of Ireland. By the courteous cooperation of the Directors of the Highland Railway Company and their Secretary, Mr. McDougall, and with funds provided by the British Association, Mr. Symons has recently been able to organize certain of their station-masters as a chain of observers running from Dunkeld to Helmsdale, 230 miles from south to north, with branches to Strome ferry on the west coast, and to Keith in the east, the distance between these two points being about 100 miles. The factor to the Earl of Breadalbane (Mr. J. P. Smith, C.E.) has undertaken to supply returns from Tyndrum and several other important stations in the vicinity of Loch Tay: several of the gauges were fixed by Mr. Symons, and the sites of others selected by him; but up to the present time no results have been received. In other parts of Scotland much has been effected through the assistance of the Secretary of the Scottish Meteorological Society, Mr. Buchan, F.R.S.E., especially in Islay and other parts of Argyle.

Especial care is taken in comparing and checking the returns; a large number of the observers (nearly a thousand) send in complete daily records, of which every entry is checked and every column recast.

The experimental inquiries as to the indications of rain-gauges of various sizes, various substances, and at various heights above the ground in Wiltshire, Lancashire, Berkshire, and Yorkshire having been concluded, the gauges are now laid up in ordinary; and should any one desire to repeat any portion of the experiments, or to vary them in any way, they will be immediately lent upon application to Mr. Symons.

Temperature of the Earth at Great Depths.—The suggestion in our last report as to the determination with extreme accuracy of the existence or otherwise of minute variations in the temperature of the earth at a depth of 1000 feet has been partially carried out, so far, that is, as relates to providing a thermometer of the requisite delicacy and strength. The instrument was exhibited at the Soirée of the Royal Society, but owing to Mr. Symons's recent illness, it has not yet been lowered to its destination.

APPENDIX IV.

DONATIONS RECEIVED DURING THE SESSION.

Presented by Societies, Institutions, &c.

Brisbane &c. ...	General Registry Office ...	Eleventh Annual Report from the Registrar-General, Queensland, on Vital Statistics, 1871.
	Observatory	Summary of Meteorological Observations, January to December 1871.
	"	Summaries of Rainfall throughout the Colony, January to November 1871.
	"	Meteorological Observations in Queensland during the year 1870.
	"	Summaries of Observations at Toowoomba, January to December 1871.
	"	Ditto at Warwick, January to September 1871.
	"	Ditto at Cape Moreton, January to September 1871.
	"	Ditto at Sweer's Island, July to December 1870, and January to June 1871.
	"	Ditto at Ravenswood, November and December 1870, and January to September 1871.
	"	Log of the Ship 'Royal Dane' during the Voyage from London to Brisbane, 1871. By E. MacDonnell, Government Meteorological Reporter.
Bruxelles.........	Académie Royale	Annuaire, 1871.
	"	Bulletins, 2e série, tomes 29, 30.
	"	Orages en Belgique en 1870. Sir John F. W. Herschel. Taille de l'Homme à Venise, pour l'âge de vingt ans. Développement de la taille humaine. Loi de périodicité de l'espèce humaine.
	Observatoire Royal	Annales, May to August 1871.
	"	Résumé des observations sur la Météorologie, 1870.
	"	Observations des Phénomènes Périodiques, 1869. By M. Ad. Quetelet, Director.
Cape of Good Hope.	Royal Observatory	Results of Meteorological Observations made at the Royal Observatory, under the superintendence of Sir Thomas Maclear. By E. J. Stone, Astronomer Royal.
Christiania	Norske Meteorologiske Institut.	Meteorologisk Aarbog for 1869, 1870.
	"	Storm-Atlas.
	"	Aarsberetning for 1870.
	"	Om Tordenvejr i Norge, 1868, 1869.
	"	Torghatten.
	"	Norges Vind- og Stormstatistik.
	"	Nogle Bemærkninger om Tordenveirenes Dannelse.
	"	Repräsentation der Imaginären der Plangeometrie.
	"	Magnetiske Undersögelser foretagne i 1868.
	"	Température de la Mer entre l'Islande, l'Écosse et la Norvége. By Professor H. Mohn, Director, and by the University.

Cincinnati	Observatory	Annual Report, June 1870. By C. Abbe, Director.
Edinburgh	Royal Observatory	Astronomical Observations, vol. xiii., 1860–70.
	"	Scottish Meteorology, 1856–71. By Professor C. P. Smyth, Astronomer Royal.
	Scottish Meteorological Society.	Journal, New Series, vol. iii., nos. 32–34.
Geneva	Société de Géographie	Le Globe, tome x., livraisons 1–6, 1871.
Greenwich	Royal Observatory	Magnetical and Meteorological Observations, 1869, 1870. By Sir G. B. Airy, K.C.B., Astronomer Royal.
Lisbon............	Academia Real das Sciencias.	Memorias, Classe de Sciencias Mathematicas, tom. i.–iv.
	"	Ditto, Classe de Sciencias Moraes, tom. i.–iii.
	"	Jornal de Sciencias Mathematicas, tom. i., ii.
	"	Catalogo das Publicaçoes.
Liverpool	Literary and Philosophical Society.	Proceedings, nos. xxiii. & xxiv.
London	Art-Union	Thirty-fifth Annual Report.
	London Institution	Journal, Nos. 7–15.
	Meteorological Office	Quarterly Weather Report, 1870.
	"	Report of the Meteorological Committee of the Royal Society, 1870.
	"	Contributions to the Knowledge of the Meteorology of Cape Horn.
	"	Currents and Surface-Temperature of the North-Atlantic Ocean. Equator to 40° N.
	"	Daily Weather Report, May 1 to June 19. By the Meteorological Committee.
	Royal Astronomical Society	Monthly Notices, vol. xxxi.
	"	Memoirs, vol. xxxix.
	"	General Index to the first Thirty-eight Vols. of Memoirs.
	Royal Institution of Great Britain.	Proceedings, vol. vi., nos. 55 & 56.
	Royal Society	Proceedings, nos. 106–134.
Madrid	Real Observatorio............	Observaciones Meteorológicas, December 1865 to November 1868.
	"	Resumen de las Observaciones Meteorológicas efectuadas en la Peninsula, December 1865 to November 1866, and December 1867 to November 1868.
	"	Anuario, 1869 and 1870. By Sr. A. Aguilar, Director.
Manchester......	Literary and Philosophical Society.	Proceedings, October 3rd, 1871, to April 16th, 1872.
Mauritius	Meteorological Society......	Notices, November 16th and 30th, 1871.
Munich	Königliche Sternwarte	Annalen, Band xviii.
	"	Verzeichniss von 3571 telescopischen Sternen.
	"	Nachweise der von 1840 bis 1869 beobachteten Zonen. By Dr. J. v. Lamont, Director.
New Haven......	Connecticut Academy of Arts and Sciences.	Transactions, vol. i. part 2, and vol. ii. part i.
Oxford............	Radcliffe Observatory	Results of Meteorological Observations, 1868. By Rev. R. Main, F.R.S., Radcliffe Observer.
Paris	Observatoire National	Bulletin Météorologique Mensuel, 1872, March, April, and May.
	" "	Bulletin International. By M. Ch. Delaunay, Director.
	Société Météorologique de France.	Annuaire, 1868, feuilles 6–10, 1869, feuilles 1–12.

Paris	Société Météorologique de France.	Nouvelles Météorologiques, 1870, October to December.
Philadelphia ...	American Philosophical Society.	Proceedings, nos. 83 to 87. Transactions, vol. xiv. parts 1 and 3.
Prague............	K. K. Sternwarte	Magnetische und meteorologische Beobachtungen, 1870. By Dr. C. Hornstein, Director.
Rome	Osservatorio del Collegio Romano.	Bullettino Meteorologico, vol. x. nos. 6–12; vol. xi. nos. 1–5. By Padre A. Secchi, Director.
St. Petersburg...	Central Physical Observatory.	Annales de l'Observatoire Physique Central, 1867 and 1868.
	" "	Jahresbericht des phys. Central-Observatoriums für 1870.
	" "	Repertorium für Meteorologie, Bd. ii. Heft 1. By H. Wild, Director.
Stockholm	Royal Swedish Academy of Science.	Meteorologiska Jakttagelser i Sverige, 1866 to 1869. By Prof. Er. Edlund.
Sydney, &c.......	Observatory	Abstract of Meteorological Observations made in New South Wales up to the end of 1869; with remarks on the Climate.
	"	Results of Meteorological Observations made in New South Wales during 1870.
	"	Monthly Meteorological Observations made at the Government Observatory, Sydney, and an Abstract from the Country Stations, 1871 January to 1872 January. By H. C. Russell, B.A., Government Astronomer.
Victoria	Royal Society..................	Transactions and Proceedings, vol. ix. part 2. Patents and Patentees, vol. iv.
Washington ...	War Department	Surgeon-General's Office, Circular, no. 3.

Presented by the Authors.

Glaisher, J., F.R.S.	Reduction of Meteorological Observations made at the Royal Horticultural Gardens, Chiswick, in the years 1826–69.
Guy, W. A......................	The Claims of Science to Public Recognition and Support.
Loomis, F. E., Ph.D.	On the Direction and Force of Wind, with the Fall of Rain and Snow, at Wallingford, Connecticut, from Observations made by B. F. Harrison, M.D.
Pengelly, W., F.R.S..........	Further Considerations of the Influence of the Moon on the Rainfall.
Pettersén, Dr. Fred.	Mean Temperature and Rainfall at San Antonio de Bexar, 1868, 1869, 1870, and 1871.
Sawyer, Fred. E.	The Climate of Brighton, being a summary of Meteorological Observations made in the Town to the end of 1870.
" "	The Climate of Brighton; a series of articles published in the 'Brighton Daily News,' from Sept. to Dec. 1871.
" "	Sussex Meteorology, 1871; a complete Summary of the Meteorological Observations made in the County, with Tables of Monthly Rainfall and Mean Temperature.
" "	Rain, with special reference to the Rainfall of Sussex, and how it is influenced by the South Downs.
Scott, R. H., M.A., F.R.S. and Galloway, W................	On the Connexion between Explosions in Collieries and Weather.
Symons, G. J..................	Monthly Meteorological Magazine, 1871.
Tebbutt, J., jun................	Meteorological Observations made at Windsor, New South Wales, 1863–66.
Waters, A. W., F.G.S.	Klimatologische Notizen über den Winter im Hochgebirge.
The Editor	'Nature,' nos. 86–104, 107, 110 117, 120–126, 137.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

April 17th.

John W. Tripe, M.D., President, in the Chair.

The Names of two Candidates for admission into the Society were read.

Mr. W. C. Nash and Mr. J. Browning were appointed Auditors of the Accounts

The two following papers were read*:—

"On the Temperature of Hill and Valley." By George Dines, F.M.S.

"On Certain Defects in Anemometric Registration." By C. O. F. Cator, M.A. F.M.S.

June 19th.

Ordinary and Annual General Meetings.

John W. Tripe, M.D., President, in the Chair.

William F. Cooper, 22 John Street, London Road, Sheffield, and Charles H. L. Woodd, F.G.S., Roslyn, Hampstead, N.W., were balloted for, and duly elected Fellows of the Society.

The names of three Candidates for Admission into the Society were read.

Captain H. Toynbee, F.R.A.S., exhibited the January, February, March, and April charts of the meteorological data collected in the 10° square of the Atlantic which lies between the equator and 10° N. and 20° and 30° W., by the various captains who have observed for the Meteorological Office since the supply of standard instruments was commenced by Admiral FitzRoy in 1854.

He said that this square was traversed by most sailing-ships and steamers that had to cross the equator, both on their outward and homeward passages, so that it was of the greatest importance to seamen.

The method followed had been to sift all the data into subsquares of 1°, and to represent it in a graphic style which conveys the facts to the eye. The hundred subsquares are numbered from 00 to 99. By this method the observations have been very quickly sorted; for instance, if an observation were taken in 0° 15′ N. and 20° 30′ W., the unit figures of the degrees of latitude and longitude have been taken for the number of the subsquare, viz. 00. Again, suppose an observation taken in 7° 48′ N. and 29° 30′ W., it is recorded in subsquare 79.

An explanation is given with each chart; but the wind-arrows speak for themselves. The seaman supposes himself at the centre of the subsquare, and the longest wind-arrow comes from the point which has the largest number of observations, whilst the others are in proportion to their number of observations. At the back of the arrow is the force of the wind by Beaufort's scale, given to a decimal, because there is a great difference between the various figures of that scale; for instance, between 4 and 5 the speed of a ship may be nearly doubled.

Besides giving the data for each subsquare, it has been thought right to give in the margins the sums of ten subsquares in both latitude and longitude. By this means the seaman can discover any differences which may exist in the direction and force of wind or current, pressure, temperature, specific gravity of the sea and weather.

He pointed out some of the important differences which were found to exist, viz.:

If in January the square were crossed by a ship keeping between 21° and 22° W., she would have a mean force of wind to drive her 2 knots an hour; but if she kept between 28° and 29° W., she would have a mean force of wind to drive her rather more than 4½ knots per hour.

		Per cent.	Wind.		Knots per hour.
Between 21° and 22°	W. she would have	28	of N.E.,	which would drive her	3
"	"	30	S.E.,	" "	2½
28° and 29°	"	46	N.E.,	" "	more than 6
"	"	41	S.E.,	" "	4½

in fact, she would be able to double her speed. It was also shown that this increase of force was gradual as you proceed from the eastern to the western side of the square.

* These papers will appear in the next Number of the Journal.

The proportion of calm to wind is shown by shading a certain number of points of the compass; for instance, if one quarter of the observations were calms, then eight of the thirty-two points of the compass would be shaded. The points selected for shading are those which have no wind-arrows, or when such are not available, then those with the shortest arrows, so that the shade-segments indicate the points which have the least or no wind, as well as the amount of calm. This method was suggested by Wilfrid Airy, Assoc. Inst. C.E.

Passing on to the chart for February, it was shown that if a ship, passing through the square, kept between 20° and 21° W., she would have a mean force of wind to drive her about $2\frac{1}{2}$ knots per hour; whilst between 27° and 28° W., the mean force amounts to a speed of about 6 knots an hour. And she would have the following percentages:—

	Per cent.	Wind.		Knots per hour.
Between 20° and 21° W. she would have	33	of N.E.,	which would drive her	$3\frac{1}{2}$
" "	15	S.E.	" "	$2\frac{3}{4}$
" "	22	N.W.	" " nearly	$3\frac{1}{4}$
27° and 28° "	80	N.E.	" "	7
" "	10	S.E.	" "	$4\frac{1}{2}$
" "	2	N.W.	" "	2

Here, again, the *force* of the north-east and south-east winds experienced on the eastern is nearly doubled on the western side of the square; and the *percentage* of N.E. wind is more than doubled. Another very important fact is that there is ten times as much north-westerly wind in the eastern strip as in the western. Now north-westerly winds are most trying to homeward-bounders, because they drive them to the eastward, where calms prevail.

In March the following results are found:—

Between 20° and 21° W. a mean force of wind to drive a ship nearly				2
29° and 30° " " more than				5
20° and 21° W. she would have	31	of N.E.,	which would drive her nearly	3
" "	23	S.E.	" " more than	2
" "	18	N.W.	" " nearly	$2\frac{1}{4}$
29° and 30° W. "	80	N.E.	" "	6
" "	5	S.E.	" "	5
" "	4	N.W.	" "	2

Here we have as great a difference as in February, and of very much the same kind.

In April we obtain the following differences:—

Between 21° and 22° W. a mean force of wind to drive a ship nearly......				2
29° and 30° W. " "				$5\frac{1}{2}$
21° and 22° W. she would have	30	of N.E.,	which would drive her more than	$2\frac{1}{2}$
" "	22	S.E.	" "	3
" "	18	N.W.	" " nearly	$2\frac{1}{2}$
29° and 30° W. "	86	N.E.	" " about	7
" "	9	S.E.	" " more than	$3\frac{1}{2}$
" "		No N.W. wind.		

So that throughout, the force of the wind is doubled in the western strip; and the differences in direction are of the greatest importance.

The charts also give the direction of currents and their speed in twenty-four hours; they clearly show that a strong westerly current prevails where the south-east wind is blowing, and a weaker one in the north-east trades; but that in the Doldrums south-easterly or easterly currents frequently prevail. In the same part light north-westerly winds are common. It is concluded that this back drift to the south-eastward is caused by the heaping-up, as it were, of the water by the two trades driving it into the Doldrums. The light north-westerly wind may arise from a somewhat similar cause, though it is well known that the air rises over the Doldrums and flows away as an upper current, which the water cannot do.

In the margins are given the weather for strips of 10°. They show that the largest percentage of thunder and lightning is at the end of the north-east trades; and that sometimes the percentage of mist in the north-east trades exceeds that in the south-east by as much as 30 or 40 per cent. They also show where the heaviest squalls and rain may be expected in each month.

Isobars and isotherms of air and sun have been drawn on small charts with the prevailing winds. They show a remarkable relation between the lowest pressure, hottest air and water, and lightest winds.

For the four months the sea has kept about 1° hotter than the air, and the two sets of isotherms agree in a most remarkable way.

The percentages of various clouds and their amount have also been given.

The chart for January has been lithographed, and a certain amount of letterpress is now in the printer's hands; when it is ready, they will be circulated for opinions before publishing.

Mr. GLAISHER said that he seldom had experienced more gratification than on the present occasion. He had had much conversation with the late Admiral FitzRoy at the first establishment of the Office, and he could only say that the results which were now exhibited were of great value. He thought Captain Toynbee preeminently fitted for the work of superintending these discussions from his long practical experience at sea.

The PRESIDENT said that he had listened to Captain Toynbee's remarks with great interest, and it appeared to him that we might soon hope that by work such as that which had been described, the science of meteorology would be placed on a solid basis.

Mr. CASELLA said that he did not understand the terms referring to the force of the wind. Captain Toynbee had spoken of percentages, of Beaufort's scale, and of miles per hour; he did not think Beaufort's scale was in general use.

Mr. SCOTT explained that percentages had nothing to do with force, and that the miles, or rather knots, per hour, referred to the rate at which a ship would be driven by the wind. As to Beaufort's scale, it was gradually becoming almost universally adopted.

Mr. GLAISHER said that he preferred the so-called land-scale 0–6, the figures of which were half those of the Beaufort scale, and afforded the additional advantage that when squared they gave approximately the pressure in pounds per square foot.

Mr. STRACHAN said that Dr. Robinson had conclusively shown that the estimation of wind-force by velocity was preferable to that by pressure, as the latter could not easily be averaged. One serious disadvantage about pressure consists, as Dr. Robinson has shown, in the fact that for small variations the increment of pressure is relatively double the corresponding increment of velocity, so that the irregularities of registration are much greater in one case than in the other.

The PRESIDENT said that the Meeting could not go into a discussion on the theory of wind-estimations, on such a paper as Captain Toynbee's.

Mr. SCOTT read three short communications, which will be found among the correspondence &c. (page 95).

The PRESIDENT then declared the Ordinary Meeting adjourned, and announced that the General Meeting had commenced.

Mr. PASTORELLI and Mr. BIRT were appointed Scrutineers of the Ballot for Officers and Council.

Mr. GLAISHER read the Report of the Council, p. 74, and the Balance-sheet, Appendix II., pp. 82–83, submitted by the Auditor, Mr. Nash.

It was proposed by Mr. CASELLA, seconded by Mr. STRACHAN, and resolved, that the Report just read be printed and circulated among the Fellows.

The PRESIDENT then read his Address, p. 70.

It was proposed by Mr. NASH, seconded by Mr. DINES, and resolved, that the President be requested to allow his Address to be printed.

Resolved:—

That the thanks of the Society be given to the Officers and Council and to the Auditor for their services during the year.

Proposed by Mr. SAWYER,
Seconded by Mr. STRACHAN.

That the marked thanks of the Society be given to the Victoria Institute for the facilities afforded for our Meetings during the past Session.

Proposed by Mr. SCOTT,
Seconded by Mr. EATON.

The President then announced the result of the Ballot, and declared the Gentlemen named in Appendix I. (p. 81) to be the Officers and Council for the ensuing year.

The Meeting was then adjourned.

CORRESPONDENCE AND NOTES.

Establishment of a Meteorological Institute in Denmark.

L'Institut Météorologique Danois,
Copenhague le 28 Mai, 1872.

Monsieur,—Par la présente j'ai l'honneur de vous annoncer que le Ministère Royal de la Marine Danoise vient d'établir à Copenhague sous les auspices d'un comité spécial un Institut météorologique pour le Danemark.

Les travaux de l'Institut vont embrasser toutes les branches de la science météorologique, et son attention sera spécialement fixé sur l'établissement d'un réseau de stations bien situées et fournies d'instruments exacts, qui pourraient envoyer tous les matins des communications télégraphiques à la station principale à Copenhague, et de même, selon convention, à l'étranger. Quand les stations seront en train régulier, les observations d'un certain nombre entre elles seront publiées mensuellement.

De même l'Institut se propose d'établir jusqu'à 6 stations météorologiques complètes sur les îles Féroennes, l'Islande et dans le Grœnland, et l'on espère d'en pouvoir établir la moitié avant l'hiver prochain. Outre l'intérêt général que présenteront ces stations, elles pourront à une époque prochaine devenir d'une grand importance pour la météorologie internationale et la prévision du temps par la submersion éventuelle d'un câble télégraphique par cette voie de l'Europe à l'Amérique du Nord. Les observations de ces stations seront publiées explicitement.

En me permettant de recommander l'Institut á votre bienveillance j'ajoute que chaque renseignement que vous désiriez, vous sera livré avec empressement, et que les publications de l'Institut vous seront envoyées régulièrement au cas que vous souhaiteriez un échange réciproque.

N. Hoffmeyer,
Directeur de l'Institut.

À Monsieur le Secrétaire de la Société Météorologique de Londres.

Note concerning Natal Rainfall. By Robert James Mann, M.D.

A coast-rainfall approaching to flood-copiousness again occurred in the colony of Natal in the month of April last (1872), being the fourth occasion of the kind within sixteen years. The fact, already alluded to in previous records printed in the Proceedings of the Meteorological Society, that these exceptionally heavy and flood-rainfalls in Natal occur in what are properly and ordinarily the dry periods of the year, has again been illustrated on this occasion. As in the case of the great Natal flood of 1856, the fall on this occasion took place in the month of April, which ranks, under ordinary circumstances in the winter, or dry season. Between the 8th and the 13th of April the fall in the coast-district was 12·57 inches, the heavy falls of the three previous occasions being, it will be remembered, for

1856.......... 27 inches.
1865.......... 8·97 „
1868.......... 16·54 „

On the 12th the water had risen so high in the river Umgeni, near the mouth, that the wooden bridge erected after the destruction of the more costly bridge by the flood of 1868 (see Proceedings, November 1868) was entirely covered, and fears were entertained that it too had been swept away. On the 13th, however, it appeared that the rude structure had successfully withstood the mighty rush of water; it had simply suffered a depression of a few inches in the middle. The flood, however, was in all probability of somewhat less urgency than in 1868; as the fall in 1868 was 16½ inches in five days, while in 1872, the present year, it was 12½ inches in five days.

The fact, also alluded to on the previous occasions, that in these heavy sea-rains of the south-eastern African coast the fall diminishes very rapidly with ascent upon the landward slope, has received likewise an additional illustration on this occasion. While the rainfall near the sea-board amounted to 12·57 inches, the rainfall at the Alz of Maritzburg, 52 miles inland and 2090 feet above the sea, was registered at my observatory as 5½ inches.

Extract from Log (2933) of Ship 'Cottica,' Captain D. F. M'Kechn[illegible], containing a Notice of the occurrence of Corposants during the Aurora of February 4, 1872. Communicated by Captain H. Toynb[illegible], F.R.A.S.

Meteorological Office, 5th June, 1872.

Date.	Hour.	Latitude. Observed.	Latitude. D. R.	Longitude. Observed.	Longitude. D. R.	Currents. Direction and temperature.	Currents. Rate.	Magnetic vari[ation] Observed.	Sh[ip's] he[ad]
1872.	2								
February	4	....	....	....	....	63°·2	....	....	S.S.
4.	6								
Sunday.	8	....	....	....	....	63·5	....	....	N.W.
	10								
	N.	32° 45′ N.	32° 56′ N.	13° 34′ W.	13° 24′ W.	63 S. 10° W.	24 m. in 2 days.	....	N.W.
	2								
	4	....	....	....	....	63	....	....	"
	6								
	8	....	....	....	....	63·6	....	....	N.W
	10								
	M.	....	....	....	....	63·1	....	....	S. by

Date.	Hour.	Winds. Direction.	Winds. Force.	Barometer. Height.	Barometer. Att. therm.	Thermometer. Dry.	Thermometer. Damp.	Clouds. Form.	Clouds. Amount.	Clouds. Direction of upper	Weat[her]
1872.	2			in.							
February	4	W.	5	30·232	65°	61°·3	61°	Cum.	10	....	o.1
4.	6										
Sunday.	8	W. by S.	5	30·254	66	62	61	Cum., cum.-s.	10	....	o.
	10										c.
	N.	W.S.W.	5	30·168	67	64·8	63·2	Cum.	9	Cir.-c.	
	2										c.
	4	"	6	30·048	67	63·2	62·2	Str., nim.	9	Cir.-c.	
	6										b.
	8	"	7	29·966	68	63·7	62·8	Str.	4	....	
	10										
	M.	W. by S.	8	29·826	64	62	62	....	......	....	

(Wind and instrumental observations uncorrected.)

Remarks.—Clear arch to N.W., of a slate-blue colour; clouds of a reddish tinge, cumulus very low, in form of flying scud.

S. G. at surface 1·0275.

Colour of the sea dark green.

8 P.M. The sky of a fiery-red colour, from N.W. to E. by the N. and up to zenith; the same as if reflecting some large fire. This appearance not caused by the sun, as it has been nearly three hours below the horizon. $10^h\ 30^m$ P.M. Wind changed to N.W., and in half an hour more back to W.S.W., during which time our royal and top-gallant yards and masts were covered with streams of electric light; even the backstays were one sheet of fire. On the yard-arms and mast-heads were balls of fire looking as large as good-sized lanterns; none of this electricity was below the top-mast head, which is 65 ft. above the sea-level. Lightning from W. to N.W.

Notes on the Climate of the South-west Coast of Africa. Communicated by Robert H. Scott, F.R.S.

2 Brandon Terrace, Southsea, Hants,
April 16, 1872.

Sir,—Having travelled along the western seaboard of the Cape Colony while engaged as an Assistant in the Admiralty Survey of that coast in 1870, and as it lies across the latitude of the belt of calms of Capricorn, in the southern summer, perhaps a short account of its meteorology may be useful to you. I speak of the coast between St. Helena Bay and the mouth of the Orange River. During the summer months (October to April) the wind blows upon the coast from S.S.W. to S.W. (mag.). This wind deposits no rain on or near the coast, though from the damp feel of it I should say it contained at times a great deal; they are accompanied almost always by cloudless skies. Sometimes they moderate at sunset, but as often continuing through the night and sometimes for weeks without intermission, always fresh, sometimes with the force of a gale; they do not penetrate more than five to ten miles inland. Barometer stands at about 30·00 inches. From April till October they drop and give place to calms and light airs, hot winds from inland, and an occasional moderate gale from the northward; fogs sometimes roll in upon the coast, with a light air from the westward. A northerly gale is generally a part of the gale blowing into Table Bay, but not nearly so violent, lasting only a few hours, and the barometer three or four tenths higher than at Table Bay. This is also the only wind which brings rain upon this part of the coast; and I think the aggregate quantity of steady rain during the year (in the summer months there is none) does not exceed forty or fifty hours. The hot winds from E.N.E. to E.S.E. (mag.) off the land are very dry and disagreeable; on one occasion they lasted eleven consecutive days, this, too, in July, when the nights on this portion of the coast (always cool) are very cold for its latitude. While these hot winds are about, the usual thing is frost (sometimes thin ice) till 7 A.M.; at 8 or 9 A.M. the wind comes off the land warm, and by noon it is disagreeably hot, dying away at 3 or 4 P.M., when the sun, although low, shines with great power till sunset, when perhaps a light cold air springs up from the sea and a frosty night sets in. During these hot winds the air is *very clear and dry* and the sky cloudless. They do not extend more than from 5 to 10 miles off shore. The barometer does not seem to be affected by them, usually standing from 30·15 to 30·20 inches. In the winter months the surf is usually heavy; and whenever the wind is upon the coast, no matter how light, a heavy, and sometimes very heavy, swell rolls in. I may add that no one ever remembered a gale right upon the coast, say, between S.W. and N.W. (mag.).

I have the honour to be, Sir,
Your obedient Servant,
J. G. Boulton,
Navigating Lieutenant R.N., and Assistant Surveyor.

Robert H. Scott, Esq., M.A., F.R.S.,
Director of the Meteorological Office.

QUARTERLY JOURNAL

OF

THE METEOROLOGICAL SOCIETY.

VOL. I. No. 4.

XI. *On the Temperature of Hill and Valley.*

By George Dines, F.M.S.

[Read April 17, 1872.]

For nearly two years past a daily register of the temperature and rainfall has been kept on the top of the Surrey hills, at Denbies, near Dorking: this register has been kindly placed at my disposal; and I propose, in this paper, to compare the results as there given with those of my own journal kept at Cobham, only a short distance from the former place, but at a much less elevation.

I will first describe the position of the instruments. Those at Denbies are 610 feet above Ordnance Datum, placed on the ridge of the Chalk Hills, in the centre of a large walled garden; the soil is a stiff loam, mixed with flints, which caps the chalk. A high beech-wood at some distance breaks off a little the force of the S.W. winds. At Cobham the instruments are placed over a lawn in front of the house, near to the river Mole, 65 feet above Ordnance Datum, close to the edge of a wide gravel walk, and partly sheltered by the house from the force of the N.E. winds. The soil is a coarse alluvial gravel, which fills up the space in the valley between the lower Bagshot sand to the north and the London clay to the south. The two places are in sight of each other, 6¼ miles distance in a straight line, the high ground sloping gradually down to the lower, without intervening hills of any magnitude. The stands are both of the same description, known as Glaisher's; the thermometers (fixed about 4 feet from the ground) are all by the same maker (Casella) and of the best description. Both stands may be considered as moderately well placed. The tops of the rain-gauges have been kept one foot above the ground.

The following Table gives the average temperature at the two places for the different months:—

TABLE of the Temperature of Hill and Valley.

	Mean of all maxima.		Mean of all minima.		Daily range.		Dry-bulb. Mean of all, 9 A.M.		Wet-bulb. Mean of all, 9 A.M.		Grains of vapour per cubic foot.		Mean degree of humidity. Saturation =100.		Rainfall.	
	Denbies.	Cobham.	Denbies.	Cobham.	Denbies.	Cobham.	Denbies.	Cobham.	Denbies.	Cobham.	Denbies.	Cobham.	Denbies.	Cobham.	Denbies.	Cobham.
1870.	°	°	°	°	°	°	°	°	°	°					in.	in.
July	75·3	77·9	53·5	53·7	21·8	24·2	65·3	67·6	59·9	61·5	4·93	5·15	70	68	1·66	1·92
August	69·7	74·4	50·8	50·1	18·9	24·3	60·0	63·5	56·6	58·4	4·65	4·72	80	73	2·99	1·94
September	64·7	68·5	47·0	44·7	17·7	23·8	56·7	56·7	54·1	54·2	4·33	4·36	84	85	2·53	1·62
October	56·5	59·4	42·5	42·2	14·0	17·2	49·7	50·4	48·0	48·3	3·58	3·58	88	86	4·52	3·54
November	46·6	49·0	35·4	33·3	11·2	15·7	41·0	39·8	39·2	39·3	2·57	2·74	90	96	2·68	1·49
December	35·7	38·8	27·3	26·2	8·4	12·6	30·8	30·8	...	...	...	...	...	...	3·99	2·55
1871.																
January	35·2	37·7	28·5	27·3	6·7	10·4	31·6	32·6	...	...	...	...	...	...	4·00	2·54
February	45·8	48·8	36·7	36·3	9·1	12·5	40·3	42·4	...	...	...	...	...	...	1·45	0·98
March	53·2	55·9	36·4	35·3	16·8	20·6	43·8	45·0	41·8	43·2	2·80	3·00	85	87	1·90	1·49
April	55·0	58·9	40·9	40·7	14·1	18·2	47·4	50·6	45·4	48·1	3·23	3·50	86	84	5·68	3·04
May	61·9	66·4	41·7	40·0	20·2	26·4	53·1	54·9	48·4	49·6	3·30	3·38	75	70	[illegible]	0·69
June	63·9	68·4	45·9	46·4	18·0	22·0	55·3	57·7	51·8	54·6	3·89	4·35	79	82	3·49	3·07
July	69·4	73·2	51·9	53·1	17·5	20·1	60·6	63·3	57·4	59·1	4·78	4·95	80	77	[illegible]	3·43
August	75·5	77·7	53·7	51·5	21·8	26·2	65·9	66·9	60·8	61·8	5·16	5·33	73	73	[illegible]	0·83
September	65·7	69·3	48·8	47·1	16·9	22·2	56·4	58·0	54·7	55·2	4·58	4·49	90	83	[illegible]	4·72
October	56·9	59·8	42·2	40·4	14·7	19·4	48·7	49·4	47·7	48·2	3·64	3·66	92	90	[illegible]	1·05
November	42·7	45·6	31·9	30·0	10·8	15·6	36·1	36·7	...	...	...	...	...	...	[illegible]	0·41
December	40·6	43·2	33·0	31·7	7·6	11·5	36·5	36·3	...	...	...	...	...	...	[illegible]	1·35
Mean of the 18 months	56·4	59·6	41·6	40·6	14·8	19·0	48·9	50·1	...	...	...	...	...	...	Sum [illegible]	Sum 36·57

Maximum Temperatures.—On looking at the Table it will be seen that the maximum temperature of the hill is below that of the valley, the difference averaging, when taken altogether, from 3 to 3½ degrees; the days on which the temperature of the hill exceeds that of the valley are very few, amounting to only 4 per cent., and I have not noticed any circumstances connected with those days that should cause the difference. The highest temperatures have been on July 8th, 1870, and August 12th, 1871; at Cobham they were 91°·4 and 91°·1, at Denbies 84°·2 and 88°·2.

The *Minimum Temperatures* are nearer together than the maximum; taken altogether the averages of the hill are 1 degree higher than those of the valley. On 251 days out of the 549 which the Table includes, the minimum has been lowest upon the hill; about 70 per cent. of that number are clearly traceable to wet and windy weather; and the assertion may be made with comparative safety that in wet, windy, or snowy weather the temperature of the hill is lower than that of the valley. But the most noticeable feature connected with this part of the subject is the great difference between the temperature of the two places in times of extreme cold, the temperature on the hill-top never descending so low as in the valley. The number of times when the temperature has been below 25° at both places has been 43; the average on these occasions upon the hill has been 23°·3 against 18°·9 at the valley station. The temperature has been six times below 10° at the lower station, giving an average of 6°, while on the hill-top upon the same nights it has averaged 15°.

On the morning of December 31st, 1870, the minimum at Cobham was

.°2, at Denbies 14°. This difference of temperature has been noticed by many observers, and, amongst others, by Gilbert White in his 'History of Selborne;' and who has not been amused at the quaint old philosopher's surprise, when, on sending his thermometer to the top of the hill to compare with his neighbour's, "they went exactly together"?

The daily range shows that the temperature of the hill is more uniform than that of the valley, and less liable to extremes, the difference amounting upon the average to $4\frac{1}{4}$°.

The 9 A.M. temperatures approach nearly to equality during the winter months; but in the summer the temperature of the valley is the higher, amounting throughout the year to an excess of about $1\frac{1}{4}$° of temperature at the lower station.

The columns of the Table which relate to the wet bulb and the moisture in the air must be received with some reserve; they are not so perfect as could have been wished. The accuracy of the records being doubtful when the temperature has descended below 32°, the winter months have been omitted from my calculations; but as a general rule the amount of vapour in the air, as far as 9 A.M. observations are concerned, does not appear to differ much at the two places; it is rather less in amount upon the hill; but, if taken relatively to the amount required to saturate the air, the valley is the drier. On those days during the winter months when I have been enabled to make the comparison, there appears to be no departure from this rule.

If the mean temperature of the two places be computed from the preceding Table, it will be found about $1\frac{1}{4}$° lower upon the hill than in the valley; but this is principally owing to the difference which prevails during the summer months; during the winter months they approach much nearer to equality.

The rainfall upon the hill has been 41 per cent. in excess of that in the valley. As the rainfall on the southern side of the Dorking hills exceeds that on the north, it appears highly probable that they intercept the rain coming from the south; and the excess might, therefore, depend upon the direction of the wind, and only occur at particular times. The direction of the wind and the rainfall being taken only once in the day, are not sufficient to make the comparison of much worth; but, as far as I could judge, the rain upon the hill-top, during steady rain, was generally in excess of that in the valley, from whatever direction the wind might blow*.

The damage caused by severe frost to vegetation in the valley, while that upon the hill-top escapes unharmed, is of too striking a character to escape notice. The popular opinion assigned for this difference is, that the air of the hill is drier than that of the valley; the figures in the Table give no foundation whatever for such an opinion, besides which, they clearly show that the temperature of the hill is less liable to extremes than that of the valley. Professor Tyndall in his Rede Lecture (see Fragments of Science, p. 204), speaking of the effect of moisture upon radiant heat uses the following words:—

* The rainfall in 1872 up to the present time has been at Denbies 34·51 in., and at the lower station 26 in.—G. D., Nov. 1, 1872.

"Wherever the air is dry we are liable to daily extremes of temperature. By day, in such places, the sun's heat reaches the earth unimpeded, and renders the maximum high; by night, on the other hand, the earth's heat escapes unhindered into space and renders the minimum low. Hence the difference between the maximum and minimum is greatest where the air is driest."

From this it follows that if the hill-tops were the drier, they would also be the colder, which they clearly are not. The different effect upon vegetation appears to be owing simply to the frosts of winter being less severe upon the hills than in the valleys.

The principal object which I had in view when commencing this paper, was to determine the difference in the amount of moisture in the air at two places so differently situated. I do not pretend to have solved this question (the observations were not sufficiently frequent), and I can therefore only recommend its solution to future observers; but there does not appear to me sufficient difference in the amount of moisture to account for the great difference of temperature. In attempting to account for this difference we are apt to be drawn aside into the region of conjecture: but we are not left altogether without guidance on the way; for on looking through the 'Proceedings of the Meteorological Society,' I find several papers which appear to have some bearing upon the subject. Amongst others, in Volume III. No. 28, is a communication from Prof. D. Ragona-Scina, Director of the Royal Observatory at Modena, "On the difference of Temperature of Two Strata of Air at unequal heights;" and again, in Vol. V. No. 46, Mr. Glaisher called attention to the different temperatures of the air at the heights of 4 feet, 22 feet, and 50 feet above the ground.

Both these papers tend to show that through the day the higher strata of air are the colder, towards evening they approach nearly to equality, but at night the higher strata of air are the warmer. Without attempting to assign any reason for these changes, I cannot help thinking that (although the irregularities of the earth's surface may distort and throw out of their otherwise natural horizontal position strata of air of comparatively even temperature) it is to this cause that the uneven temperature of hill and valley recorded in this paper must be assigned.

I have been particular in describing the situation of the two places where the observations have been taken, as the question will occur to many, Is there any thing exceptional at either that would affect the observations here given? This can only be determined by other observations at different places. With good instruments meteorological observations require little but care and attention on the part of the observer to make them valuable; to draw correct conclusions from those observations is more difficult. The climatic differences which no doubt exist at many of our most celebrated watering-places are at present but imperfectly understood, and we are in danger of assuming certain conditions as necessary to health. This paper will not be without its value, if it only calls more pointed attention to the discrepancies which difference of elevation may cause when the best observations are compared together.

XII. *On certain Defects in Anemometric Registration.*

By CHARLES O. F. CATOR, M.A., F.M.S.

[Read April 17, 1872.]

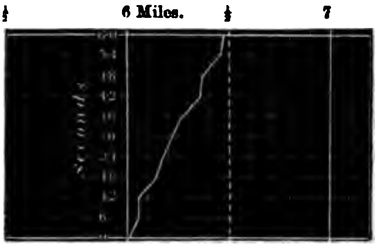
THE subject of anemometers and their mode of registration having occupied my thoughts and attention for a considerable amount of time, and the Rev. F. W. Stow having, in his valuable paper read before this Society at the January Meeting, brought to our notice one branch of this large and confessedly difficult subject, viz. the relative merits of different sizes of cup-anemometers, I trust it may not be deemed out of place if I venture to offer a few remarks on another branch of it, viz. the modes of registration obtained from the different kinds of instruments in use. I do not propose to discuss the mechanism of the different kinds of pressure-, nor of the different kinds of cup-anemometers, but the *mode of registration* as given by anemometers which register the pressure of wind, as compared with that given by those which register the horizontal movement of the air, and the defects of each mode.

The main object, whether it is deduced from one kind or the other, appears to be to obtain a true picture-record of what takes place in nature, or the actual variations of the force of the wind expressed graphically by a pencil during every moment of the 24 hours.

1st. As to anemometers which register the *horizontal movement of the air*; and here I would venture to observe that this is a more appropriate designation of the element measured than "velocity," which is simply a deduction from it. The mode of registration of these instruments is well known, *i. e.* by curves traced on paper ruled with parallel lines in one direction to represent the hours of the day, and parallel lines at right angles to them to represent the number of miles. Although the record thus given would describe the actual motion of the air, but for the suggested serious defect to be mentioned presently, yet (even if such defect should not exist) for all practical purposes the result is merely the total mileage, as calculated from the number of revolutions of the cups in different periods, *i. e.* a day or hour, or any such small period as could be readily discerned by the eye on paper of the usual compass; and this brings me to the first defect, viz. that the changes of wind which take place within a less period than can be seen by the eye on the paper are not shown, and therefore we should remain in ignorance of these quick but important changes in such small periods if there were no other means of telling us. To show the changes in small periods, say of less than five minutes, the paper would have to be lengthened; and in order to show gusts, which are generally momentary, and cannot possibly be shown on the papers of ordinary size, it would seem that the paper would have to be of enormous length—in fact, of such a length as would render it quite unmanageable and utterly unfit for use. The smallest required size would, I conceive, have to be in length about one inch for a minute, which would be 5 feet for 1 hour, and 40 yards for 24 hours! the width of the paper being,

say, such that 1 inch would represent only 1 mile; and even a paper of these dimensions would not show *all* the movements *plainly*: see specimen

Fig. 1.



at fig. 1, where the following supposed case of a separate movement for every 6 seconds is shown, say:—

1st period of 6 secs.,	4 lbs. on sq. ft. = 30 miles per hour,	or ·05 mile in 6 secs.	
2nd „	Calm = Calm,	„ 0	„
3rd „	10 lbs. on sq. ft. = 47 miles per hour,	„ ·08	„
4th „	2 „ = 20 „	„ ·03	„
5th „	4 „ = 30 „	„ ·05	„
6th „	4 „ = 30 „	„ ·05	„
7th „	16 „ = 60 „	„ ·10	„
8th „	Calm = Calm,	„ 0	„
9th „	10 lbs. on sq. ft. = 47 miles per hour,	„ ·08	„
10th „	2 „ = 20 „	„ ·03	„
	Average rate 28·4 „	Total ·47 mile in 1 min.	

Now it would appear that these small variations of the wind which are so lost form a very important condition of the air, which should be known, as it is these momentary gusts which do all the damage to trees, chimney-tops, roofs, &c. It is therefore very essential to know the maximum velocity of these gusts. With regard to the blowing down of trees, I have observed that this more frequently occurs with gales from a quarter to the S. of S.W. than from a quarter to the W. of it, the strength being supposed about the same from each, the former being of a more intermittent character than the latter, as will be more fully shown hereafter; as a confirmation of this, I have been informed that Mr. Glaisher has also observed that trees are more generally blown down by winds whose gusts come at regular intervals.

Again, no doubt the trace, as shown on the recording-sheet in general use, gives exactly a true record of the number of revolutions of the cups; but it is a question whether these revolutions show a true mileage. Dr. Robinson, in his paper on this subject in vol. xxii. of the 'Transactions of the Royal Irish Academy,' calculates that the velocity of the cups is one third of that of the wind, whatever be the size of the cups and length of the arm; and this probably, as a general rule, is as accurate a statement as it is possible to get from experiments. Mr. Glaisher also made some

experiments in Greenwich Park by fixing a set of cups to a long arm, which was made to revolve round a post 5 feet high in reverse directions; the mean of the two results was taken, and the revolutions, whether rapid or slow, appeared to produce almost the same result; this went far to confirm Dr. Robinson's theory.

But, notwithstanding this, can the above deduction be considered absolutely correct, or any thing more than hypothetical?

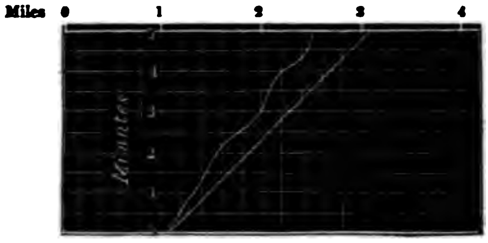
I am here reminded of Mr. Stow's paper, from which I gathered that the results of his experiments were quite irreconcilable with Dr. Robinson's law, and that cup-anemometers with different lengths of arm, and with cups of different sizes and weights, all gave so far different results from those of the instrument which he took as a standard and from each other (most of the instruments having small arms only moving through one fourth of the space passed over by the wind), that the supposed relation between the velocity of the wind and of the cups could not be relied on with such certainty as heretofore. If this relation therefore, hitherto supposed to be correct, is now rendered of a doubtful character, ought the practical results of this class of anemometers to be considered as valuable as hitherto? and is not another probable defect thus exposed, which calls for some remedy?

Next, I will refer to the defect alluded to above, and what appears to me to be a much more serious, if not *the* most serious, defect. Is it not a fact that the cups, from their momentum, when once set in motion by a gust or wind of any strength, continue to revolve, after the gust has partially or completely subsided, at a greater rate (and sometimes at a much greater rate) than the actual velocity of the wind, if any, then existing would cause them to revolve? For instance, suppose, for one second, a gust of, say, fifty miles an hour causes the cups to revolve at a certain rate, and therefore the pencil on the paper to move over a corresponding very small space which cannot be discerned by the eye, and that the next moment there is a lull: it is manifest, from observation and from reasoning, that the cups could not stop or revolve at a correspondingly slower rate so instantaneously after the gust as they ought to do to give a true result; they would continue to move on (from the momentum given to them in the first instance) during the interval of lull, at first *almost* as fast as they did while the gust occurred, and afterwards at a decreasing rate, and therefore a wrong result is shown on the paper; and the same thing might be repeated several times in the shortest period, say x minutes, whose corresponding space on the paper could be easily seen.

For example, let the pencil of any self-registering cup-anemometer in use show in any five minutes that the horizontal motion of the air had been 2 miles (or an hourly velocity of 24 miles); the result which ought to be shown, if a true record were given, would be as traced in fig. 2, showing for some moments, perhaps, a velocity of 40 or 50, and for others 5 or 10 miles an hour, or perhaps calm, and the aggregate motion, perhaps, 1½ mile only, instead of 2.

On the other hand, I am aware that a certain amount of friction has to

Fig. 2.



be overcome in the first instance, after a calm, on the immediate commencement of a gust, or on the immediate increase in the velocity; and accordingly from this cause a *less* number of miles than had actually passed would be recorded; but the comparatively small error from this cause would, I apprehend, be much more than counterbalanced by the other error, viz. that from the momentum, so that the net result would still be too great a mileage.

Referring once more to Mr. Stow's paper, in which, if I remember rightly, he told us from his observations that, except in low velocities, larger cups generally registered a less mileage than smaller ones, the radius or arm being of the same length. This seems to me an unlooked-for result; for, from mechanical principles, the opposite would naturally appear to be the case, because the greater momentum of the larger cups, when set in motion, would be expected to produce a greater number of revolutions; and a somewhat similar and familiar instance may be mentioned, viz. that of a grindstone, which, as every one knows, the thicker and therefore heavier it is, the more difficult it is to set in motion, but when once in motion the longer it will continue to revolve. In this case, as in the cups, the thicker it is, although of the same radius, the more resistance it receives from the air; but still the greater momentum, in this instance also, much more than compensates the greater resistance to the air.

The conclusion appears to be, that, by the present mode of registering from cup-anemometers, the number of revolutions described as due to the force of the wind gives on paper, or dials, a larger corresponding number of miles than have really passed.

I now come to consider the registration as shown by an anemometer for measuring the *pressure* of the wind. This is also shown on paper which has parallel lines in one direction for the hours of the day, and parallel lines at right angles to them for showing the number of pounds and fractions of a pound pressure. These last are generally so arranged that the small pressures have a larger space to each pound, for the sake of showing the fractions of a pound, than the spaces allotted to the higher numbers.

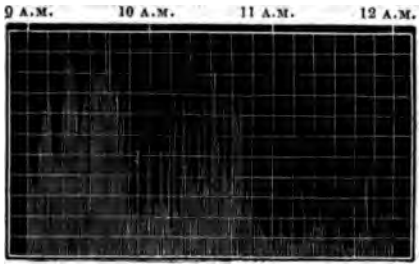
The record of these anemometers likewise does not show plainly the actual variations in the force of the wind in detail, although they are traced by the pencil, because the paper, for the sake of convenience, is generally not of sufficiently large size; and consequently, as the gusts come very frequently (sometimes as many as twenty in five minutes), the pencil travels repeatedly over the same line, while the paper remains, so to speak, in the

same position, and thus the short lines representing light gusts are hidden by the long lines representing strong ones; and the consequence is, that in very windy weather the spaces become very black from the frequent motion of the pencil over the same part of the paper. This is no doubt a defect; but it is capable of being remedied so as to show each gust distinctly, or at any rate more distinctly than at present, by having the hour-spaces of the paper sufficiently increased in length; and I imagine the size required would not be so unwieldy as would be required to remedy the corresponding defect in cup-anemometers, nor so unwieldy as to be incapable of being applied to the pressure-instruments. No doubt it is an inconvenience; but it is one which, I think, might be overcome.

There is another defect in pressure-anemometers, viz. the great difficulty of having an instrument so delicate as to show the minute movements of the air when it is very nearly calm, *i. e.* when the pressure is at or less than one or two ounces. But this defect appears to be of little consequence.

On the recording-papers as used at present, the traces left by the pencil are thus (see fig. 3), by which it will be seen that only the maximum gusts

Fig. 3.



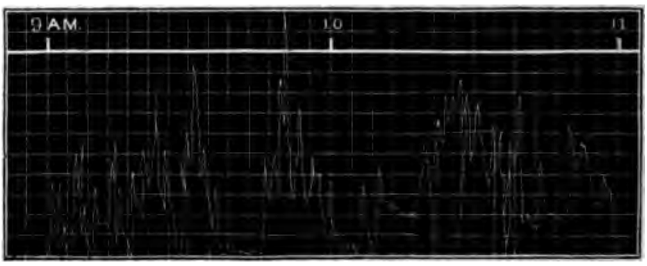
during each minute or so are actually visible until the paper has been carried through such a space that the next movement of the pencil is clear from the trace of the preceding gust; and it is generally the case, that the whole of the area of the paper, between the extremes traced by the pencil and the zero-line, is blacked in, because, the time-space being so small, the paper has not had time to move on between the successive gusts before the pencil comes down again to the zero-line. This, however, is not the case with wind from all directions, as will be mentioned presently.

Although the pencil does of itself actually trace the variations in the strength of the wind, yet the marks left on the paper do not show all the details, on paper of limited size, for the reason just mentioned.

It may be objected that even the pencil of the pressure-anemometers does not really trace all the gusts and lulls in detail. The answer to this is, that the construction of the instrument necessarily provides for it; because that part which acts as the resistance to the wind (viz. springs or a weight, as the case may be) of itself instantly brings the pencil back from the maximum point of gust down to a lower pressure, or to zero, according to the amount by which the wind's force has abated. If a recording-paper of sufficient length, say $2\frac{1}{2}$ or 3 inches for each hour, were adopted, so as to show all the gusts, and to have the whole course traced

by the pencil without one gust overlapping another, the curve so traced would be something like this (see fig. 4). By this means, what has generally been considered to be an impossibility, viz. to get the mean pressure for the twenty-four hours, might be arrived at with close approximation to the truth; for the mean of each minute or few minutes might be adopted with great certainty by the eye, and so the mean for the twenty-four hours could be calculated from all the means of such small periods much more nearly than at present.

Fig. 4.



Here would seem to be a fitting place to remark on the different character of the tracings produced by the wind from different directions. When the wind is N.W., I have observed its strength to be more "continuous" than when it blows from any other quarter, *i.e.* the pencil very seldom comes down to the zero-line before the next gust follows; so that in this case the paper is not all blacked in, as in the previous instance, nor do the gusts overlap each other quite so much as with wind from other quarters; but the variation in the force of the wind from such a quarter, N.W., when traced would be as in fig. 5. When the wind is S.E., it is more

Fig. 5.

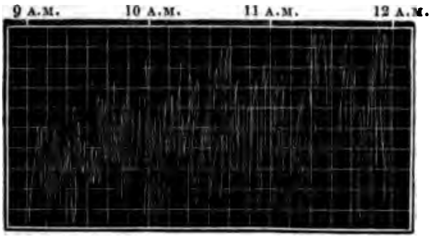
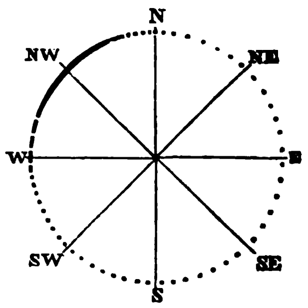


Fig. 6.



"intermittent," that is to say, the pencil nearly always reaches the zero-line between the several gusts, and so the variations in the force traced by the wind from such a direction would be as in fig. 3 (see above), showing the paper to be entirely blacked in; and according as the wind blows from the points of the compass nearer to N.W. or S.E., on the S.W. side, so it partakes of a more "continuous" or "intermittent" character respectively, and the results would be shown on the paper accordingly. The wind from all quarters on the N.E. side appears to partake of the S.E. character (see fig. 6).

I made some similar remarks in a paper read before this Society in February of 1869, but then put them forward merely as suggestions. They have all since been fully corroborated by subsequent observation; and I have also had this view confirmed *aliunde*, *i. e.* from comparison of the results of my anemometer with the results of that at Greenwich.

In a gale it is extremely interesting to observe the almost uninterrupted movement of the pressure-pencil up and down (at one instant up, perhaps to the point corresponding to 10, 20, or 25 lbs., and the next instant down to 1 or 2 lbs., or it may be to zero), and so mark in these movements nature telling graphically her own tale.

CORRESPONDENCE AND NOTES.

The Rev. W. Clement Ley has published the first part of a work on the Laws of the Winds prevailing in Western Europe*, which is intended to express results which the author has obtained from the construction and study of a system of daily weather-charts carried on for many consecutive years. The long-observed universality of the rules which connect the direction of surface-winds with the relative distribution of surrounding pressures is regarded as warranting the assumption, on which the author proceeds throughout, that an inquiry into the configuration, extent, and interdependence of the Barometric Areas (or the atmospheric spaces inclosed in isobars) and an investigation of the rules which govern their development and alteration is the proper preliminary to the examination of the laws of resulting currents.

The division of the work is based on the broad natural distinction existing between the areas of low and those of high pressure. These differ from one another not only in the direction of the air-currents, the currents of the former being "*cyclonic*" and those of the latter "*anti-cyclonic*," but in other characteristics, one of the most remarkable of which is this, that the depression-areas are, in ordinary circumstances, distinctly *progressive*, traversing the surface of the globe according to definable laws; while the areas of high pressure, when of large dimensions, are often *stationary*, or nearly so, for a considerable period, and when of small, are dependent for their alteration of geographical position upon the neighbouring systems of depression. This first part is devoted to the examination of the laws of formation and progress of areas of barometric depression. It is intended that the second should be descriptive of the anti-cyclonic systems, of the inter-relation of the areas of both classes, and, finally, of the laws by which the velocity of atmospheric currents is related to the steepness of barometric gradients.

Instances from time to time occur in which the primary development of well-formed systems of depression takes place within the limits of regular observation. The atmospheric conditions antecedent to every such case have been subjected to minute analysis. It is found that while certain other conditions exert a very important influence in checking or promoting these developments, there is only one invariable antecedent, viz. the production of an extensive cloud-bank with *precipitation occurring simultaneously over a wide surface.* To such precipitation, therefore, acting in conjunction with the influence of the earth's rotation, the primary development of depression-systems is theoretically and practically traced.

The disturbing effects, however, which extensive precipitation produces upon the surface-winds are not found to be in uniform relation to its *amount*, but appear to decrease with augmentation, and to increase with diminution of the general *temperature* of the atmosphere.

The progress of depression-systems over the earth's surface is the next subject of inquiry. The author has failed to discover that regular transference of the whole atmosphere relatively to the surface of the earth from W. to E. which many

* 'The Laws of the Winds prevailing in Western Europe,' by W. Clement Ley, with charts, diagrams, &c. Part I. London: Stanford.

meteorologists suppose to exist. That the ordinary eastward advance of the depression-systems of our own latitudes is not due to any such general transference, seems to be proved by the following considerations:—1st. The velocity of the progress of depression-areas is frequently enormously in excess of that of the general movement of the neighbouring currents. 2nd. While the depressions are advancing with great rapidity, corresponding areas of high pressure in their vicinity are frequently stationary. 3rd. In "polar periods," when the prevailing distribution of pressure in our latitudes is reversed, pressures being elevated over the extreme north of the Atlantic or of the continent of Europe, and depressed in the south, and when consequently the general set of the currents is from E. to W., the local depressions, though retarded, continue to travel from W. to E.

The march of the depressions is, indeed, *affected* by the position of extensive anticyclonic systems, every depression advancing with greatest facility in the direction in which it has the highest general pressures on the right of its course, and thus tending to sweep round the great areas of high pressure. Yet the progress of depressions is, to a great extent, independent of the motion of the adjacent portions of the atmosphere, and is evidently self-developed—that is to say, it is due to a principle of motion which has its origin in the depressions themselves.

This independent progress is also traced to precipitation as its principal factor; and it is shown that "the changes in their capacity for aqueous vapour which the currents of every depression undergo, in consequence of the unequal distribution of solar heat, themselves propagate the depression in an eastward direction."

From the continued combination and comparison of the tracks taken between the barometric minima across Europe, certain "mean lines of atmospheric progression" have been deduced. These lines are found to be subject to *seasonal variations*, which are exhibited in charts showing the prevailing tracks of the minima in March, August, and December. The nature of these seasonal variations is described at some length, and it is shown that the general tendency of depressions is to advance at an angle of about 45° towards the lower mean isothermals.

Besides their seasonal variations, these mean lines or tracks tend to converge towards particular districts, especially towards the more mountainous regions, which appear to exercise both an attractive and a detentive influence on depressions. An endeavour is made to trace these local and geographical influences by an inquiry into the relative number of depressions traversing particular districts, and the percentages of detention or delay within the limits of such districts.

About one half of the volume is occupied by the description of actual instances of the primary formation and subsequent development of depression-systems, those examples being selected for examination which most nearly approach typical completeness and perfection. These are illustrated by synoptic barograms, and by charts showing the course and alteration of the isobars, the upper and undercurrents &c., and the tracks eventually taken by the barometric minima.

A final chapter is devoted to the consideration of upper currents. The author has endeavoured to discover what is the general relation prevailing between the motions of the higher strata of the atmosphere and the distribution of atmospheric pressures at the earth's surface, by a classification of numerous upper currents according to their observed position with respect to the neighbouring areas of high and low pressure. The principal result is this—that "the higher currents, while moving commonly, and in a general way, with the highest pressures (as observed at the earth's surface) on the right of their course, yet manifest a very distinct centrifugal tendency over the areas of low pressure, and a centripetal over those of high."

It is shown, however, incipient or very limited cyclonic systems frequently fail to affect the direction of the upper currents, and also that there is reason to believe that the axis of a progressive depression has commonly such an inclination that the portion of the system nearest to the earth's surface is in advance of that which is at a great elevation. An attempt is made to account theoretically for the results thus obtained.

Dr. R. Angus Smith, F.R.S., has given the public the results of a long experience in the analysis of air in his work 'Air and Rain*.'

As regards the constitution of the air, which is generally said to be 79 per cent. of nitrogen and 21 per cent. of oxygen, he finds that air from any open space contains 20·9 per cent. of oxygen, but that in confined spaces the amount is far less,

* 'Air and Rain, the Beginnings of a Chemical Climatology,' by Robert Angus Smith, Ph.D., F.R.S., F.C.S. London: Longmans.

as low as 20·7 per cent. in the pit of a theatre, and even 18·27 per cent. in one instance in a mine. This, however, was the most vitiated specimen of any that Dr. Smith has tested. He shows that the difference between 20·999 and 20·980 per cent. of oxygen in air is really 190 parts in a million, a very appreciable quantity, and also a very important one, if at any time the difference is made up by noxious gases, considering how large an amount of air passes through the lungs in the process of continuous breathing.

Dr. Smith gives copious Tables of the varying proportions of carbonic acid: he says that ordinary good ventilation in a house means air with less than ·07 of carbonic acid. In general, the proportion of carbonic acid gas in the atmosphere varies between ·145 per cent., the average in tunnels of the Metropolitan Railway, and ·033 per cent., the average on the Scotch hills.

In the analysis of 339 specimens of air from mines, the average amount of oxygen proved to be only 20·26 per cent., and not more than 11 per cent. of the air in these cases could be called normal air.

Dr. Smith gives an account of some observations of his own on air contained in a closed lead chamber, with analyses of it after being breathed for a certain time by one or more persons, and after being allowed to get into such a state that candles and gas would not burn in it.

Copious Tables of the varying composition of rain-water are given; but no very important conclusions appear to have been yet drawn from the observations recorded. Chlorides occur in sea-coast rain; inland the sulphates seem to increase. The proportion of sulphates to chlorides is not, in any case, that of sea-water; the salts are, therefore, not referable to sea-spray. The free sulphuric acid found in air near towns is not held to be necessarily an indication of the presence of manufactures in those places. The figures of the crystals obtained by the evaporation of rain-water at Newcastle, indicate the presence of sulphate of soda. In Manchester there are flakes of oxide of iron in the rain, and in London a network of crystals which yield sal ammoniac on ignition. The observations of these crystals suggested the idea of shaking water in a bottle full of air for the collection of its impurities. For medical purposes this process has to be continued until enough of the impurity is collected for examination and analysis.

Prof. Reye, of the University of Strasburg, has published a work on storms*, which deserves notice. As its title shows, its object is to explain the origin of storms, and to show how closely they resemble the cyclones in the sun's atmosphere. The text (if it may be so called) of the book is furnished by the frontispiece, which is a reproduction of a cut given by Olmsted, and which represents a number of small whirlwinds, resembling waterspouts, which the observer once saw over a burning cane-brake in Alabama. Prof. Reye deals first with small whirlwinds, dust-storms, and "trombes," whose origin he attributes to the existence of a state of unstable equilibrium in the atmosphere, frequently produced when the soil has been much heated on a hot summer's day; in such a case the ascending current not uncommonly assumes a gyratory motion, like that which Olmsted observed to be generated by the burning of the cane-brake.

Waterspouts and tornados are next shown to differ from these small whirlwinds simply in degree; and from this point the author proceeds to deal with the true cyclones, whose origin he traces to similar causes acting on a more extended scale. The book contains copious extracts from the works of Reid, Piddington, and others. It appears that, on the whole, he considers all our European storms to be true cyclones; he distinctly refers the north-westers of the north coast of Germany to this category. It is, however, probable that he is not familiar with all that has been written on European storms; he quotes 'Mohn's Storm Atlas,' but does not allude to Buchan and other known writers of authority.

Prof. Reye is most strongly opposed to the views of Thom and Meldrum, who refer the generation of cyclonic storms to two currents of air flowing beside each other in opposite directions; the explanations of storms given both by Dove and Espy find little favour with him: on the whole, his own interpretation of the phenomena most closely resembles that of the American physicist.

The chapter on solar cyclones is a good brief *résumé* of what is known of the perturbations of the sun's atmosphere.

The Appendix contains mathematical investigation of:—1. The expansion of air

* Die Wirbelstürme, Tornados und Wettersäulen in der Erd-Atmosphäre, mit Berücksichtigung der Stürme in der Sonnen-Atmosphäre. Hannover, Rümpler, 1872.

in the formation of clouds; 2. The law of expansion of moist air; 3. The unstable equilibrium of the air; 4. The velocity of ascending air-currents.

The Journal of the Austrian Meteorological Society contains many valuable papers. Regnault's paper on Hygrometry* has been reproduced, in which he says that he has not much to add to his former statements given in the 'Annales de Physique,' &c., 3rd series, vol. xv. p. 129, and that he still holds De Saussure's hair hygrometer to be the best apparatus for the purpose, provided it is tested from time to time. He insists that the wet-bulb thermometer should be set up in the open air without any screen or protection, and also points out the necessity for maintaining a constant current of air during the observation. The substance of the paper consists of a description of a method for determining the weight of vapour in a given volume of air, which is measured by an aspirator and collected in a tube filled with sulphuric pumice. He employs a clockwork arrangement, by means of which the air can be made to pass through several distinct tubes in turn, if the amount of moisture be wanted for successive periods of equal duration. The method seems to be very exact and satisfactory.

The Journal also contains a translation of a paper by Dufour, on the proportion between Evaporation and Rainfall, which appeared in the Bull. Soc. Vaud. Sci. Nat. vol. x. p. 233.

The author says that he first commenced the investigation nine years ago, but that it was not till 1865 that his apparatus, the "Siccimeter," was perfected. It consists of two cylinders of zinc, of which the upper fits into the lower. The latter, A, is 19·7 inches in diameter and 9·84 inches in depth; the upper, B, is a pan of the same area, being only 3·15 inches deep, and it fits 0·8 inch deep into A, to which it acts as a sort of cover, having two handles. A flange is attached, to prevent any water which runs down the outside of B getting into A. A tube of 0·06 inch diameter passes through the centre of B; it is bent at the top, which is 0·79 inch below the rim of the pan, but passes down nearly to the bottom of A. When rain falls into B, the level of the water rises to that of the mouth of the tube, and the surplus quantity is collected in B. When in use, the pan is filled with water up to the level of the tube-mouth, and is then left to itself in the open air. In order to make an observation after any interval of time, the pan B is removed, and the depth of water in both B and A measured; the difference between this and the quantity originally introduced, gives the information required: the tube is only 0·09 square inch in area; so as the entire area of B is 773·6 square inches, the diminution of surface due to the tube may be neglected. The rim is nearly level with the ground. Of course, if no rain has fallen since the last measurement, B need not be lifted, and a simple measurement of the water in it will suffice. In regard to frost, it was found, by direct experiment, that the evaporation from ice was very slight, and on this account the instrument was usually taken in till the thaw came on. Actual experiments on ice were made by leaving only a thin stratum of water in B, so as to prevent damage to the pan by the expansion of the ice.

Snow causes great inconvenience, from the risk of drifting, and also of the collection of water in B, which does not properly belong to it, during thaw, when the whole apparatus is covered with snow. The cylinder A has a depth of 9·84 inches; but it would probably be preferable to employ a greater depth, for fear of heavy falls of rain and a consequent overflow.

The rate of evaporation in a vessel depends on the distance between the rim of the vessel and the surface of the liquid; the evaporation is greatest when the liquid is flush with the rim, but then there is danger of loss by means of ripples caused by wind: 0·79 inch was found, on the whole, a satisfactory distance, and, in order to keep the water up to the mark, the readings were taken at intervals of two days, and water added when requisite. The effect of *insolation* was a cause of error on hot days; the temperature of the water in B then rose considerably. The rate of evaporation in the instrument is influenced by the amount of clear sky.

No appreciable loss of water was caused by evaporation from A. Dust forms a coating over B, and retards evaporation; this is obviated by constant renewal of the water.

It is evident that the exposure of the siccimeter must be as carefully looked to as that of the rain-gauge.

* Bibliothèque Universelle de Genève, vol. xi. p. 229.

It must also be remembered that the instrument can only give results for a free water-surface, and not for the soil, as the latter gives off water freely when wet, but very slowly when comparatively dry.

M. Dufour discusses the difference which must exist between evaporation from a lake and that shown by his apparatus, and concludes with some general remarks on the observations, pointing out that four years is too short a period to give really valuable results.

Dr. Hann continues his notices of the meteorology of isolated districts: he gives an appendix to his former papers on South America, in the shape of a notice of the climate of Chiloe and the Chonos Islands, taken from a paper by Capt. Vidal Gormáz, published in the Report of the Marine Ministry of Chili for 1870. The mean temperature of Ancud (in Chiloe) is 10°·3 C., being 0°·7 C. less than that of Puerto Montt, which lies 20′ to the north of it, but on the mainland. This shows that Gillis's statements as to the climate were based on incorrect data. The temperature of New Zealand, on the same parallel, is 1° C. warmer; the annual range is very small, the difference between the extreme monthly means being scarcely 7° C.; the weather is wet and unpleasant; the rainfall is said to be as large as in any situation outside the torrid zone.

Another paper relates to Japan, and gives the meteorological data for Yokohama, Decima, and Nefa, being a continuation of a paper in last year's volume on the same subject.

Dr. Hann contributes some remarks on the Distribution of Heat over the Southern Hemisphere, which are introduced in allusion to the three thermal charts of the globe, taken from 'Buchan's Handy Book.'

He quotes the generally received opinion, that the southern hemisphere is on the whole cooler than the northern, and shows that it has arisen from a misconception of Dove's meaning, when he said, "As far as 40° S. the temperature of the southern hemisphere is lower than that of the northern, a relation which appears to be reversed in the higher latitudes. With reference to the areas of the respective zones, the northern hemisphere is warmer than the southern." Dr. Hann shows that *the southern hemisphere is warmer than the northern in the higher latitudes, and that this relation holds good as far as to the antarctic continent.* He points out that in high latitudes the sea is warmer than the land, while the reverse holds true nearer to the Equator. He remarks, that if an average of the known mean temperatures on the meridians of New Zealand and of the west coast of South America be taken, and the means for corresponding latitudes in the northern hemisphere be compared with it, the following differences are found:—

Latitude	40°	45°	50°	55°
Southern hemisphere..	54°·5	50°·4	46°·2	41°·7
Northern hemisphere..	56 ·5	49 ·1	41 ·7	36 ·0
Difference	+ 2 ·0	− 1 ·3	− 4 ·5	− 5 ·7

This arises mainly from the fact that in high southern latitudes, although the summer is cool, the winter is, relatively, much warmer than in similar parallels on the other side of the Equator.

Dr. Wojeikoff gives an interesting paper on the winds of Northern Asia, in which he criticizes Wild's views, and argues that the S.W. winds towards the north indicate a low barometer to the northward, and, therefore, probably an open sea. The south of Siberia has easterly winds, over which the existence of a south-west current is rendered visible by the drift of the clouds, especially at Orenburg. He does not consider this polar wind to have any connexion with the N.E. monsoon, as he cannot see how the current can cross the mountain-chain. Four distinct regions of climate are described:—

I. Prevalent equatorial winds: North Siberia, as far east as the Yenissei and down to lat. 51° S.

II. Prevalent polar winds: the Steppes and Central Asia. These regions have a belt of high barometer between them.

III. Region of calms, around the Pole of cold: the Lena district, and that beyon the Baikal Lake.

IV. The winter-monsoon region on the east coast: from the sea of Ochotzk dow to China, with cold dry N.W. winds.

Dr. Wojeikoff gives another paper on the Trade-winds, the Tropical Rains, an the Subtropical Zone, in which he traces out four distinct rain-districts for th North Atlantic, namely:—

1. That of Equatorial Rains, from 0°–10° and 12° N. lat., caused by the *courant ascendant* partly during the whole year and partly in special months.
2. Rainless Trade-wind district, 10°–12° N. to 28° N.
3. Subtropical Zone, 28°–40° N.
4. That of Rain at all seasons, N. of 40°.

The final deductions from the paper are, that:—

A. The Trade-wind circulation of the atmosphere, with the maximum baro metrical pressure in 30° N., is preeminently oceanic.

B. This is not only much disturbed by the presence of the continents, but woul be materially changed were the earth's surface mainly composed of dry land, i which case there would be broader trade-wind zones, with greater thermic di ferences at their extreme edges.

C. Between the tropics, at sea, the rainy season only follows the change of pos tion of the calm zone, at the utmost from 12° N. to 5° S.

D. The tropical rains, north and south of this zone, are due to disturbances i the regular course of the trade-winds, produced by the influence of the land.

E. The desert of Sahara owes its rainlessness, not to the continental origin (the trade-wind, but to the Mediterranean Sea, especially in summer.

F. The subtropical zone is also an especially oceanic phenomenon, only develope at sea and on the west coasts of continents. Its absence in Eastern and Centr Asia is due to a fundamental difference in the meteorological conditions.

Considerable changes are in progress in the meteorological organizations (various countries. In France, M. Jules Simon has reversed the action of th Imperial Government, and placed the entire meteorological system under th Observatoire de Paris. The Observatory of Montsouris, which C. Ste.-Clai Deville had established with much care, has been placed under the Observator and most of the meteorological work of the latter establishment has been tran ferred to it. The Bulletin International is now dated from Montsouris, but th series of observations at the Paris Observatory has not been suspended. M. C. Ste Claire Deville has been appointed Inspector-General of all the French Meteoro logical Stations, except those in connexion with the telegraphic system.

In Denmark, as was noticed in the last number of the Quarterly Journal, Cap N. Hoffmeyer has been placed at the head of the newly organized Institute.

In Sweden, the intention of the Government to establish a central institute i Stockholm in the year 1873 is announced, and the Observatory at Upsala is to b the central station.

In Berlin arrangements are reported to be in progress for the founding of a mo complete meteorological organization than that now existing, which is of old dat and is in connexion with the Statistical Bureau.

The only country in Europe which does not seem to be included in this promi of an organized meteorological system is Greece; but Dr. Julius Schmidt, Direct of the Observatory at Athens, has published some notices of the climate of Greece which have been reproduced in Abstract in the Journal of the Austrian Meteoro logical Society.

Professor Alluard makes the announcement that he is about to erect, at the to of the Puy de Dôme, in Auvergne, a Meteorological Observatory. As this mountai rises to a height of about 3000 feet above the surrounding country, a very inter esting opportunity will there be furnished for ascertaining how far the simultaneou observations taken at a high and low level will throw light on the influence of heigh in modifying various meteorological conditions. There is a low-level station of ob servation at Clermont, at the foot of the mountain.

* Beiträge zur physikalischen Geographie von Griechenland. 2 vols. Athens: 18(and 1864.

Donations received from July to October.

Presented by Societies, Institutions, &c.

Batavia	Observatory	Magnetical and Meterological Observations. Vol i. By Dr. P. A Bergsma, Director.
Bruxelles	Observatoire Royal	Annales. September 1871. By M. A. Quetelet, Director.
Copenhagen	K. Landhus-holdnings Selskab.	Fem-aars-beretning 1866–1870. By Poul la Cour, Sub-Director.
Dorpat	Kaiserliche Universität	Meteorologische Beobachtungen, 1866, 1870, and 1871. By Dr. A. v. Oettingen.
Edinburgh	Scottish Meteorological Society.	Journal, New Series, nos. 18 and 35.
Liverpool	Literary and Philosophical Society.	Proceedings, no. xxv.
London	London Institution	Journal, No. 16.
	Meteorological Office	Daily Weather Report and Charts.
	"	Quarterly Weather Report, 1871. Part i.
	"	Report of the Meteorological Committee of the Royal Society, 1871.
	"	Chart of Meteorological Data for No. 3 Square, January, with Remarks to accompany it.
	"	A Discussion of the Meteorology of the part of the Atlantic lying north of 30° N. for the Eleven Days ending 8th of February, 1870, by means of synoptic charts, diagrams, and extracts from logs, with remarks and conclusions, by Capt. H. Toynbee. By the Meteorological Committee.
	Royal Society	Proceedings, nos. 135–137.
Oxford	Radcliffe Observatory	Results of Meteorological Observations, 1869.
	" "	Observations of Shooting-Stars, 1869–71. By Rev. R. Main, F.R.S., Radcliffe Observer.
Paris	Observatoire National	Bulletin International.
	" "	Bulletin Mensuel, 1872, May, July, and Sept.
Prague	K. K. Sternwarte	Magnetische und meteorologische Beobachtungen, 1871. By Dr. C. Hornstein, Director.
Rome	Osservatorio del Collegio Romano.	Bullettino Meteorologico, vol. xi. nos. 6–9. By Padre A. Secchi, Director.
St. Louis	National Agricultural Congress.	Address of Com. M. F. Maury, LL.D., May 1872.
St. Petersburg	Central Physical Observatory.	Repertorium für Meteorologie, Bd. ii. Heft 2. By H. Wild, Director.
Southport	Literary and Philosophical Society.	Laws.
Sydney	Observatory	Results of Meteorological Observations made in New South Wales during 1871.
	"	Monthly Meteorological Observations made at the Government Observatory, Sydney, and an Abstract from the Country Stations, 1872 February to June. By H. C. Russell, B.A., Government Astronomer.
Tiflis	Imperial Observatory	Materialien zu einer Klimatologie des Kaukasus, Abth. iii. Bd. 1.

Tiflis	Imperial Observatory	Schemacha und seine Erdbeben. By Dr. A. Moritz, Director.
Victoria	General Registry Office	Abstracts of Specifications. Metals. Part i. William Henry Archer, Registrar-General.
Vienna	Oesterreichische Gesellschaft für Meteorologie.	Zeitschrift, Band i., Band ii. Nos. 10–14, 16–24; Bd. iv. 1-7, 18–24; Bd. v. 1–8, 18–24. By Dr. C. Jelinek.
Washington	Smithsonian Institution	Report for 1870. By Professor J. Henry, Secretary.
	War Department	Report of Chief Signal-Officer, 1871. By Brigadier-General Myer, U.S.A.
Wellington, N.Z.	General Registry Office	Statistics of New Zealand, 1870. J. B. Bennett, Registrar-General.

Presented by Individuals.

Buchan, A.	Annual Opening Address to the Botanical Society, Edinburgh, Nov. 9th, 1871.
Eaton, H. S., M.A.	Ballooning, by Charles Green.
"	Normal Winds of Bombay, by C. Chambers, F.R.S.
"	Notes on the Solar Eclipse of July 18th, 1860, by G. J. Symons.
"	Tweeddale Prize Essay on the Rainfall, by T. F. Jamieson.
Edwin, Com. R. A., R.N.	Meteorological Journals of the late Augustus Edwin, 1855 to 1871.
Hornstein, Dr.	Ueber den Einfluss der Electricität der Sonne auf den Barometerstand.
Hume-Rothery, Rev. Wm.	Vaccination and the Vaccination Laws.
Ley, Rev. W. Clement	The Laws of the Winds prevailing in Western Europe, by W. C. Ley. Part i.
Ryerson, Rev. E., D.D.	Journal of Education, Ontario, 1872, March to June.
The Editor	Food Journal, Nos. 30–33.
"	'Nature,' to end of October.

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[. No. 5.

On the Storms experienced by the Submarine Cable Expedition in *le Persian Gulf on Nov. 1st and 2nd,* 1869. By LATIMER CLARK, I.Inst.C.E., F.M.S.

[Received July 15, 1872. Read November 20, 1872.]

:E laying a submarine telegraph cable from Jask to Bushire in the in Gulf in 1869, the author twice experienced a peculiar storm, panied in one, and probably in both, instances by a form of cloud r to that described by M. Poey and commented on by Mr. Scott*. phenomena were seen under very favourable circumstances, and may to throw some further light on the character of this form of cloud. irst storm overtook the expedition on the 1st of November about ., when nearly 130 miles from Bushire. The weather had for many been settled and fine, with a high barometer and strong morning es, dying off in the afternoon to a dead calm. Distant lightning and heavy clouds were occasionally seen in the N.W. On the night in ion the sun had set as usual on a calm sea, and the cable was being out steadily from a large sailing-vessel, the 'Calcutta,' towed by a ful steamer, the 'Dacca,' when suddenly, and without the smallest ng, both vessels were struck by a blast of cold air mixed with scat- rain, which brought them up standing as effectually as if they had gainst a wall. For a few minutes a scene of great confusion followed. s impossible to stand without holding on to some fixed object; awn- nd wind-sails were carried away or had to be cut adrift, and loose s of every kind were overthrown and hurled along the deck; the f the tempest was so loud that commands were inaudible; the steamer e unmanageable, being encumbered by a steam-barge in tow, which be cut adrift, and both she and the 'Calcutta,' presenting broadsides

* *Vide* page 55.

to the wind, were carried bodily leeward. After struggling ineffectually against the storm for an hour and a quarter, and after losing a good deal of cable, which was payed out in a backward direction, it was thought best to cut and buoy the cable, and the 'Dacca,' having got up more steam, towed her consort in under the land for shelter. In the meantime the thermometer had fallen nearly 30°, and a tempest of thunder and lightning burst over the vessels on a scale of great grandeur and beauty, which, as the vessel's masts and rigging were all of iron, could be enjoyed without apprehension; the flashes averaged thirty or forty per minute, and the roll of the thunder was incessant. Many of the flashes appeared to drop into the ocean perpendicularly as a single stream of fire enlarged at the point where it struck the water. From their distance and apparent altitude some of these flashes were estimated to have fallen from a height of 1000 feet. They were followed by rapid interchanges of electricity among the clouds above, as if the disturbed equilibrium were readjusting itself. Other flashes appeared to originate, like the sources of a river, in a thousand separate streams which, uniting together, joined into one apparent trunk and fell into the sea, presenting the appearance of a genealogical tree. One flash in particular extended its branches out horizontally to a wider extent than the eye could take in, so that for an instant the whole visible heavens were filled with innumerable streams of fire converging into a common trunk and descending into the water. All the flashes seemed to be double; and some were repeated three or four times, but at such rapid intervals that they could not be counted, but appeared, as it were, to flicker. Some flashes struck the 'Calcutta,' and although only visible to those on board as a dazzling and blinding light, as viewed from the sister ship the whole upper part of her masts and rigging were apparently clothed with fire. Some few flashes were seen distinctly to rise out of the ocean and striking straight upwards to disperse themselves among the clouds. The lightning lasted half an hour in its greatest intensity, and then drifted away with the storm to the S.E. The tempest after lasting two hours changed into a gale from the E. and S.E., which by morning had subsided into a calm.

The next day the cable was spliced up, and paying out had scarcely commenced, with a strong S.E. wind, when notice was received that another violent storm from the N.W. had passed Bushire and was on its way down the gulf. Full steam was accordingly got up, awnings were taken in, and every preparation made for its reception. At 3 P.M. black clouds were seen rising, and at 3.52 P.M. the storm burst forth with the same suddenness and fury that had characterized the previous one: being daylight many phenomena were observed which were missed the previous night. As the clouds approached they gathered into a peculiar form resembling the cap of a large mushroom, extending entirely across the heavens from one horizon to the other. The lower edge of the mushroom had a rounded and wrinkled margin, but was very sharply defined: the surface was composed of many similar strata, as if melted pitch had been poured out and allowed to solidify in numerous cakes, each rather smaller than the one below. Underneath

all there was a dark chaos which soon enveloped the vessels, the wind still blowing aft. Suddenly there came a profound calm, and a few hundred yards ahead the squall was seen approaching. The sea, elsewhere covered with full-sized waves, under the influence of the hurricane became one dead level of creamy foam, the top of every wave being swept off into spray as soon as it rose. Small whirlwinds swept along the surface carrying up waterspouts towards the clouds, and for a few moments the darkness and the breathless calm contrasting with the threatening of the approaching squall, and the lurid light of the sky still gleaming behind, formed a very impressive scene, which was heightened by the incessant roll of distant thunder. In another moment the squall struck the vessels with the same fury as on the previous occasion, and the thermometer fell at once from 81° to 53°; torrents of rain swept the decks, accompanied with continuous flashes of lightning and peals of thunder and a recurrence of all the appearances of the previous night. The vessels, however, steamed ahead with full power, and were enabled to maintain their way successfully, losing a length of four miles of cable. After about two hours the sky grew bright and the wind changed into a gale from the S.E. followed by a calm. One or two phenomena were noticed out of ordinary course. The barometer remained on both occasions unaffected up to the last moment; but as soon as the storm arrived it rose about two tenths of an inch, and fell again when it had passed over, thus showing that the propelling power was pressure from behind, produced by the weight of the falling rain or some other cause, and not vacuum in front, as in ordinary storms. It was noticed that the thunder caused by those flashes of lightning which struck the vessels did not follow the flash instantaneously, but after a very perceptible interval of time, showing that from some cause the lightning travelled the last 400 feet or 500 feet in silence. Another circumstance of a technical character still more unexpected was that the electrical instruments connected with the cable were not affected during the storm, although they were of the most sensitive construction, and were ranged in a manner well suited to show any effects if they had existed. The vessel and rigging were of iron, and the cable was coiled in iron tanks riveted to the sides of the vessel; yet even when the discharges were sufficient to burn pieces of canvas on the rigging, none of the electricity appeared inclined to enter the cable, but the whole escaped silently to the sea without causing even a quiver of the galvanic needle, thus recalling to recollection Faraday's celebrated observation, that the whole quantity of electricity in a flash of lightning is not greater than that caused by the decomposition of a single drop of water.

The discussion on this paper will be found at p. 123.

XIV. *On the Meteorology of Southland, New Zealand, in* 1871. By Charles Rous Marten, F.M.S.

[Received August 7, 1872. Read November 20, 1872.]

Meteorological Observations at the Martendale Observatory in 1871.
Lat. 46° 17′ S., long. 168° 0′ E.; elevation 79 ft.; distance from sea 10 miles.

General Remarks.—The splendid weather which had prevailed during the last five months of 1870 continued uninterruptedly during the first four months of 1871 (the temperature sometimes rising to 86° in shade and 162° in sun), not terminating until May 4th, when the temperature was as high as 71° in shade (the highest in May for ten years), and the barometer had fallen in four days from 30·44 in. to 29·01 in. That night a heavy flood occurred (2·39 inches in twelve hours) followed by a snow-storm of 2 inches. The remainder of May was very wet and stormy, with strong westerly gales on the 18th, 22nd, and 29th, the last gale being preceded by a fall of the barometer to 28·88 in. June was fine, dry, and calm throughout, with sharp frosts. July was constantly wet, with much hail, snow, thunder, and lightning, but no strong wind; the mean height of the barometer was the lowest monthly mean on record =29·410 in.; the barometer fell to 28·552 in. on 18th, and 28·790 in. on 26th, and was below 29 inches on eight days in the month; no perceptible results followed the barometric depression of the 26th. A month of very fine weather intervened between July 23rd and August 24th, when a severe storm of snow, hail, thunder, and lightning occurred, and the weather was continuously bad up to the 17th of September, with a great deal of snow; an unusually heavy snow-storm was experienced on September 5th, to the depth of 5¼ inches. The latter half of September was fine, the first three weeks of October very wet and stormy, and the last ten days of the same month very fine and bright. November and December were cold, windy, and showery; rain fell almost daily, but in quantity so small that there was a serious deficiency at the close of the year. September, October, November, and December, taken together, formed the coldest and most ungenial spring experienced in thirteen years, although the rainfall was much under the average. Snow fell on the 19th of November. December was remarkable for the two severe storms which occurred within ten days of one another. The first (on the morning of the 12th) was preceded by a barometric fall to 28·90 in.; the wind blew from due N., and was the heaviest gale for three years, maximum pressure 37 lbs. The force was, however, insignificant compared with that of the terrific hurricane of the 23rd, which far exceeded in violence any gale hitherto known in Southland. The barometer on the 22nd fell rapidly, reaching 28·99 in. at midnight, when the gale set in from N., blew violently for two hours, when it abated, but at 8 A.M. suddenly increased to a furious hurricane from N.W. to W., which blew from about 9.30 A.M. to 12.30 P.M. with unprecedented force. The anemometer (Robinson's, by Negretti and Zambra, measuring from 0·01 mile to 1000·0 miles) showed a current of 246 miles to have passed in those three hours, and in the strongest gusts (of not more than a few seconds' duration) the velocity was from 50 to 5[illegible]

yards per second, or 100 to 107 miles an hour, representing a pressure of 50 to 52 lbs. per square foot. The gale abated gradually from 1 P.M. until sunset, when it ceased. Great damage was done throughout the country. No rain accompanied the gale, which was very widely felt.

The mean height of the barometer was neither more nor less than the adopted average. The range was no less than 2·014 inches, *i. e.* from 30·566 to 28·552 inches.

The mean temperature of the air was 50°, which is precisely the same as 1870, and 1°·5 below the average of twelve years, and 4° lower than 1860 and 1861, but 1° higher than 1868.

The mean temperature of solar radiation was 114°·2, or 54°·5 above the mean shade maximum; the mean terrestrial radiation was 30°·7, or 9°·6 below the mean shade minimum.

The mean humidity =·75, was ·1 above the average.

The rainfall was 39·03 in., or 5·26 in. less than the average of twelve years; it fell on 144 days, or 4 more than the average number.

Gales or high winds occurred on 11 days in the year, thunder 18, snow 10, hail 24, fog 1, earthquakes 2 (on April 19th at 4.55 P.M., two rather sharp shocks, and on the following morning at 1 A.M. another smart shock). Aurora and meteors very frequent, the former of almost nightly occurrence at several parts of the year; they were specially noted and described on 35 nights.

The amount of ozone (by Schönbein's ozonometer) was 7·6.

1871.	Barometer.	Thermometer. In shade.				Thermometer. Exposed.		Hygrometer.	Rain.		Wind.									Ozone.	General.				
	Mean, cor. and red. 32° and sea-level.	Maximum.	Minimum.	Mean.	Daily range.	Maximum in sun.	Minimum on grass.	Humidity 0—1.	Inches.	Days.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Miles daily.	Mean 0—10.	Snow.	Hail.	Fog.	Thunder.	Gales.
	in.	°	°	°	°	°	°																		
Jan. ...	29·998	86	33	60·0	22·9	162	22	·69	1·39	4	2	1	0	15	0	0	8	5	105	6·3	0	0	0	1	0
Feb. ...	·865	81	35	56·3	21·9	156	24	·76	2·89	12	0	0	0	12	0	0	12	4	146	7·3	0	0	0	0	0
Mar. ...	29·872	78	32	55·7	20·8	152	20	·74	3·08	10	1	0	4	15	0	0	7	4	112	6·9	0	0	1	1	0
Apr. ...	30·105	73	29	52·0	23·4	129	17	·72	0·96	5	2	0	8	7	0	0	7	6	143	7·3	0	0	0	0	0
May ...	29·763	71	26	46·4	16·8	124	16	·78	7·74	20	4	0	3	0	0	0	17	7	212	8·4	1	4	0	1	3
June ...	·822	63	21	40·7	15·9	103	9	·86	1·53	9	1	2	13	2	0	0	7	5	87	7·0	0	1	0	0	0
July ...	·410	59	23	42·2	16·3	103	10	·82	6·30	17	2	0	4	3	0	0	14	8	152	8·8	2	7	0	7	0
Aug. ...	·726	67	25	44·3	15·4	116	13	·82	3·44	13	9	0	4	2	0	0	5	11	173	7·8	2	4	0	4	[illegible]
Sept. ...	·848	64	24	46·2	19·0	129	12	·79	2·77	10	6	1	3	7	0	0	9	4	137	8·0	4	3	0	0	2
Oct. ...	·609	72	33	49·3	18·3	142	21	·69	3·24	18	2	0	0	3	0	1	17	8	214	8·1	0	1	0	1	2
Nov. ...	·833	76	29	52·0	23·4	148	18	·69	2·79	10	4	0	2	3	0	1	15	5	159	7·6	1	4	0	1	0
Dec. ...	·725	76	38	54·3	18·8	146	25	·70	2·90	16	3	0	0	2	0	0	16	10	262	7·2	0	0	0	2	2
Year ...	29·798	86	21	50·0	19·4	162	9	·75	39·03	144	36	4	41	71	0	2	134	77	158	7·6	10	24	1	18	11

N.B. The Southland Observatory is the most southern in the world at present.

The discussion on this paper will be found at p. 124.

XV. *On a Self-registering Tide-gauge and Electrical Barograph**.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer, Sydney.

[Received July 15, 1872. Read November 20, 1872.]

(Abstract.)

The author has forwarded to the Society rough sections and photographs of two instruments he had recently invented. He hopes that both, but especially the barograph, may be useful to many who cannot afford the photobarograph, and who are desirous of seeing its indications at the moment rather than waiting till the next day for the development of the sheet.

The tide-gauge requires but little explanation. A scale of 12 inches was photographed with it and serves to indicate its size. The large wheel is attached to, and turns with, the cylinder, 1 foot of circumference (or rise and fall of tide) being equal to 2 inches on the paper. The pencil in its guide-frame moves along the two bars above the cylinder by the descent of a small weight, and the function of the clock is to regulate the motion to the rate of 1 inch per hour.

The barograph, though not so simple, is very effective. The tube of the barometer is fixed to the frame of the instrument, and its cistern, a small glass vessel (kept in position by an arm, on or with which it has perfectly free motion up and down, but none sideways) floats in a large reservoir of mercury, and its rise or fall is conveyed to the frame carrying the pencil by a long arm, which magnifies the motion.

The clock has an eccentric revolving at a short interval; this has an arm and another frame, which moves backwards and forwards in a horizontal plane, and can be brought to touch the arm from the barometer cistern, while at the same time it moves the pencil-frame.

The portion of the frame which touches the barometer-arm is an inclined plane, so that, as it moves backwards and forwards, the interval during which the two remain in contact varies with the level at which the barometer-arm is situated, or with the height of the barometer. As long as the two are in contact an electromagnet is at work, which brings down the pencil on the cylinder and makes a mark whose length varies as described.

The delicacy of this barograph was shown by a comparison of its indications with the photographic curve; it leaves nothing to be desired. By altering the inclination of the inclined plane, the scale may be made as long as desired; and it costs far less time and money to work it than the photographic barograph.

The discussion on this paper will be found at p. 124.

* A notice of this instrument has also appeared in 'Nature.'

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 20th, 1872.

Ordinary Meeting.

John W. Tripe, M.D., President, in the Chair.

Henry Tylston Hodgson, Harpenden, St. Albans; William Cumberland Hughes, Saint Bees, Cumberland; John Lee Jardine, Capel, Surrey; John Merrifield, Ph.D., F.R.A.S., Gascoyne Place, Plymouth; Richard J. Nelson, Kent Terrace, Kendal; Mansfield Turner, Claremont Buildings, Shrewsbury; and James M. Wilson, M.A., F.R.A.S., Hillmorton Road, Rugby, were balloted for, and duly elected Fellows of the Society.

The names of the five Candidates for Admission into the Society were read.

The following papers were then read:—

"On the Storms experienced by the Submarine Cable Expedition in the Persian Gulf on Nov. 1st and 2nd, 1869." By Latimer Clark, M.Inst.C.E., F.M.S. (p. 117).

The President said that he considered the Meeting was much indebted to Mr. Clark for his paper, and drew attention to that part of it which contained the remark "that the fact of the telegraphic apparatus not being affected by the lightning was an illustration of Faraday's statement, that the quantity of electricity in the most vivid flash of lightning was not equal to that generated by the decomposition of a single drop of water." He expressed his belief that the masts and the vessel being of iron and the instruments insulated, their non-affection was not to be taken as an indication of the quantity of electricity contained in a flash of lightning, and without doubting Faraday's statement, wished for an expression of opinion on the subject.

Dr. Mann observed that the iron vessel, with its tall iron masts and rigging, would obviously act as an efficient lightning-rod of large capacity, and conduct the lightning quietly to the sea, under conditions which would scarcely allow perceptible influence upon telegraph-needles. In any case of injury to telegraphic apparatus from lightning, duly protected by a lightning-rod, the discharge is generally brought from a distance by the telegraph wire. But in the case under notice this form of conveyance was impossible; in the first place because the cable was immersed in the ocean, and then because it seemed at the time to have been severed from the signalling apparatus. The apparatus was, therefore, doubly safe, in as far as it had no channel for conveyance of the lightning discharge from a distance, and as it did possess an admirable "paratonnerre" in the masts, shrouds, and water-immersed hull of the ship.

Mr. Walker said that the telegraphic instruments were safe during this thunderstorm, because they formed no part of a circuit available for the lighting; they had been insulated by cutting the cable.

Mr. Casella drew attention to the suddenness of the shock of the storm, which reminded him of an account of a similarly sudden storm experienced by Capt. Furnell in the ship 'Seringapatam' in the Indian Ocean.

The President alluded to the remarkable observations contained in the paper, that the barometer had not risen on the approach of the storm, that it rose whilst it was in progress, and that immediately after it was over it fell to its usual level. He inquired if similar occurrences had been observed elsewhere when storms were preceded by the appearance of clouds such as those described in the paper.

Mr. Eaton said that the late Colonel Sykes had told him of a storm at Bombay on the 6th of April, 1848, resembling that under discussion in several features. There had been frequent lightning and thunder in the course of the evening, and on a sudden change of wind from S.W. to N.E. at 9 P.M., the wind setting in as a gale for twenty minutes, the barometer rose 0·1 inch, rapidly descending again on the termination of the storm to nearly its former level. At the outburst of the gale the temperature declined 10°, and there was a heavy fall of rain.

Mr. Scott said that the records of Mr. Whitehouse's microbarograph published in the Royal Society's 'Proceedings' for 1871, exhibited a sudden rise of pressure which accompanied thunderstorms. The particular form of cloud mentioned had been noticed at a time of serious electrical disturbances, as had been abundantly shown by the discussion in February last.

Mr. Symons said that he had noticed somewhat similar irregularities of pressure

on self-recording barometers, especially on the records of the Oxford barograph. The formation of the festooned cloud might possibly be connected with it, as it had been noticed that the appearance of such a cloud had accompanied disturbances of tidal action.

Dr. MANN considered that the rise of the barometer was certainly due to the shift of wind from an ex-equatorial to an ex-polar direction. A similar change at the time of a thunderstorm is constantly observed in the South-African region of frequent thunderstorms.

"On the Meteorology of Southland, New Zealand, in 1871." By Charles Rous Marten, F.M.S. (p. 120.)

The PRESIDENT, referring to the amount of ozone, 7·6, said there was very little ozone in London; and expressed his doubts as to the dependence to be placed on the records. He then said, the only occasion on which his test-paper was coloured to the maximum on the scale, was on the evening of the Peace Rejoicings, in May 1856, when a great quantity of fireworks were let off only half a mile distant. It was very remarkable that fog occurred only on one day in the year, which is quite a contrast to London, especially at this time of the year when fogs are so prevalent. The great height of temperature was also remarkable. It would be valuable to contrast the day and night range of temperature with the public health there, as a great daily range of temperature is very injurious to health.

Mr. CASELLA said that with respect to ozone, from the observations he had made, it seemed that no reliance could be placed upon the results. A gentleman had told him that when he observed his test-papers in the early morning they were deeply coloured, but became bleached as the day advanced.

Rev. F. W. STOW observed, that when residing on the Yorkshire coast he nearly always had an amount of ozone exceeding the maximum on Schönbein's scale.

Mr. SYMONS stated that the colour gets washed out of the ozone test-papers by the early morning dew. He had not heard the daily range of temperature at Southland, but thought the large difference between the minimum in air and that on grass, showing such great radiation at night, was an indication that the daily range was in excess of that in this country.

Mr. SCOTT said it would be well if some one would read a paper on ozone before the Society.

"On a Self-registering Tide-gauge and Electrical Barograph." By H. C. Russell, B.A., Government Astronomer, Sydney. (p. 122.)

Mr. SYMONS remarked that there were various objections to the instrument, and thought it was not practical, on account of the great amount of friction which must arise from so many levers being employed; the motive power was also rather small. He did not know how the scale was obtained, unless by comparison with the readings of another barometer; in which case it would be arbitrary. He was also much surprised to hear that it was inexpensive; for, from the description, he should have inferred that much delicate workmanship was required.

Mr. STRACHAN said he agreed with Mr. Symons as to the imperfections of the instrument. The trouble would not be so great as with the photographic barograph, and it would not be so expensive to keep in working order. The instrument appeared to be very ingenious. The tide-gauge was like one made by Adie.

Mr. SCOTT, by invitation of the President, gave an account of the proceedings at the Meteorological Conference held at Leipzig in August, and stated that the organ of the Conference, and of the arrangements for the proposed Congress at Vienna next September, would be the Journal of the Austrian Meteorological Society. He also informed the Meeting that a complete English translation of the Report of the Proceedings would be prepared shortly after the appearance of the German original, and would be published by the Meteorological Committee as one of their non-official papers.

Mr. SYMONS suggested that it would be very desirable to appropriate one of the evening meetings for the discussion of the various matters contained in the Report which Mr. Scott had so kindly promised to place within the reach of the public.

The Meeting was then adjourned.

CORRESPONDENCE AND NOTES.

A DISCUSSION OF THE METEOROLOGY OF THE PART OF THE ATLANTIC LYING N. OF 30° N., FOR THE ELEVEN DAYS ENDING 8TH OF FEBRUARY, 1870, BY MEANS OF SYNOPTIC CHARTS, DIAGRAMS, AND EXTRACTS FROM LOGS, WITH REMARKS AND CONCLUSIONS. BY CAPTAIN H. TOYNBEE, F.R.A.S. (Published by E. STANFORD, Charing Cross.)

This work forms No. 13 of the official publications issued by the Meteorological Office. Its introductory remarks tell us that it was undertaken on account of the various reports of bad weather, which came into the Office about the time when the S.S. 'City of Boston' disappeared; that steamer, having left Halifax, Nova Scotia, on the 28th of January, 1870, has not been heard of since.

The method followed has been to give extracts from about thirty logs each day, which are followed by a few remarks; a daily chart shows the direction and force of the wind, the weather, sea, &c., experienced by each ship, as well as by various stations on shore, at 8 A.M. G. T. Isobars and isotherms of sea-temperature have been drawn when possible. Five diagrams show continuous records of wind, weather, &c. experienced by five ships during their passages across the Atlantic. A reduction of all the charts, placed under each other for ease of comparison, shows how the wind- and weather-changes originated on the American coast and advanced to the north-eastward across the Atlantic, at the rate of about 30 miles an hour.

The American winter snowstorms are shown to be related to two areas of high pressure, one over the American land, the other over the sea to the northward of the N.E. trades, between which runs the hot Gulf-stream, having over it a lower pressure. The prevailing wind to the eastward of the first-named area of high pressure is shown on the charts to be northerly; whilst the wind to the westward of the other is southerly. These counter currents of air seem to be coming constantly in collision, causing eddies, which travel to the north-eastward along the coast, and pass out into the Atlantic, giving the coast bitter northerly winds and snowstorms, at times when ships on the eastern sides of the eddies are experiencing heavy southerly gales. It is remarked that in summer the high pressure over the American land is replaced by a low one, whilst that to the northward of the N.E. trades remains, so that the element for a northerly wind disappears and southerly winds prevail on the coast, which accounts for their hot summers.

The paper calls attention to the fact that Mr. Meldrum, of the Mauritius, proves that the hurricanes of the Southern Indian Ocean also take their rise between two counter currents of air having a lower pressure between them, which seems to be also true of the West-Indian hurricanes.

The question is raised as to whether the apparent travelling of an eddy or cyclone may not be the result of the constant formation of new eddies along the point of contact when two currents of air are closing on each other, in somewhat the same way as the point of contact between the two sides of a pair of scissors advances when closing them.

During the eleven days dealt with by this paper five of these cyclonic gales were formed and their north-easterly routes proved. It points out that during the eleven days southerly winds prevailed in the British Islands, though they were frequently disturbed or intensified by the passage of these areas of low pressure as they took a north-easterly course to the westward of Ireland. It supposes that they are drawn towards the area of low pressure which prevails in the neighbourhood of Iceland during our winter months.

After the 8th of February an easterly wind set in over the British Islands; and although the charts end on that day, running extracts have been given from several logs, which seem to prove that the easterly wind worked its way slowly to the south-westward, but that it did not check the formation of eddies near the American coast; they seem, however, to have taken a more northerly route in their passage to the north-eastward.

A few practical hints are given for navigators, and the paper ends with the remark that it is only "a first attempt at the style of work which is needed to connect the excellent observations now being taken in America with those of Europe." The hope is expressed that the commanders and owners of our large lines of steamers traversing the Atlantic will take up the subject, accept the offer of the loan of standard instruments from the Committee of the Royal Society, who

manage the Meteorological Office, and for at least a year record useful observations which may be dealt with in a similar manner. To make this more easy, it is added that if the keeping of an extra log on board steamers so constantly in port be thought too much trouble, the Office would be satisfied with the loan of ship's logs recording observations of its standard instruments.

RELATION BETWEEN THE VELOCITY OF THE WIND AND ATMOSPHERIC PRESSURE. BY M. RAGONA, DIRECTOR OF THE OBSERVATORY AT MODENA. BULLETIN OF THE 'ASSOCIATION SCIENTIFIQUE DE FRANCE,' NO. 260, 29TH DEC., 1872.

Having discussed a series of eight years' barometrical observations and of five years' anemometrical observations, both made by self-recording instruments, I have represented the general means of the two series by Bessel's formula, and drawn the corresponding curves.

Fixing my attention upon the inflexions of the anemometrical curve, that is, on the changes of sign of the second differences, I have found that these inflexions are intimately connected with the barometrical phases.

The annual curve of the atmospheric pressure gives, in the course of the year, three maxima M and three minima *m*, which occur at the following epochs:—

M, 14th January;	*m*, 28th March.
M, 27th May;	*m*, 20th July.
M, 23rd September;	*m*, 14th November.

The annual curve of the wind's velocity gives six inflexions at the following epochs:—

a, from − to +, 14th December;	*b*, from + to −, 26th February;
c, from − to +, 15th May;	*d*, from + to −, 14th July;
e, from − to +, 20th August;	*f*, from + to −, 26th October.

If we take the mean of the latter inflexions, we get

$$\frac{a+b}{2} = \text{23rd January}; \qquad \frac{b+c}{2} = \text{6th April};$$

$$\frac{c+d}{2} = \text{14th June}; \qquad \frac{d+e}{2} = \text{6th August};$$

$$\frac{e+f}{2} = \text{27th September}; \qquad \frac{f+a}{2} = \text{20th November}.$$

We see then (having regard to the number of observations, and to the entirely different methods for arriving at the same results) that the intermediate epochs of two adjacent inflexions approximate closely to the barometrical phases. The mean distance between the epochs A and B is 10 days, and those of B are always subsequent to those of A.

It is worthy of remark that the comparison of the annual curves of the barometer and anemometer shows that the maxima of the former correspond to the minima of the latter, and *vice versâ*.

I have found exactly the same correspondence between the daily curve of the wind's velocity and that of the barometer. The annual diurnal curve of the anemometer gives four inflexions at the following times:—

$$a,\ 23^{h}{\cdot}32;\ b,\ 9^{h}{\cdot}85;\ c,\ 12^{h}{\cdot}71;\ d,\ 16^{h}{\cdot}86.$$

By taking the mean of these times we get

$$\frac{a+b}{2} = 4^{h}{\cdot}6; \qquad \frac{b+c}{2} = 11^{h}{\cdot}3;$$

$$\frac{c+d}{2} = 14^{h}{\cdot}8; \qquad \frac{d+a}{2} = 20^{h}{\cdot}1.$$

which are very near the annual tropical hours of the atmospheric pressure at Modena.

I have wished to try the same study for the seasons. In making the calculation for the winter, which is the season of the greatest anemometrical variations, I

have immediately found the confirmation of the law. The curve of the wind's velocity in winter gives the following inflexions:—

$$a,\ 23^{h}{\cdot}82;\ b,\ 6^{h}{\cdot}60;\ c,\ 14^{h}{\cdot}85;\ d,\ 20^{h}{\cdot}15.$$

The mean of these times is

$$\frac{a+b}{2}=3^{h}{\cdot}2;\quad \frac{b+c}{2}=10^{h}{\cdot}7;$$

$$\frac{c+d}{2}=17^{h}{\cdot}5;\quad \frac{d+a}{2}=22^{h}{\cdot}0;$$

which are *exactly* the tropical barometrical hours of the winter at Modena.

M. Peslin, Ingénieur des Mines at Tarbes, the author of a paper on the ascent of heated air and the physical modifications induced thereby in it, which appeared in the Bulletin of the 'Association Scientifique,' vol. iii. p. 299, has published in the 'Bulletin International' another treatise on the "relations between barometrical variations and the great currents of the atmosphere," for the purposes of comparison with Mr. Ferrel's and Prof. Everett's papers in 'Nature' *. It is almost entirely theoretical; M. Peslin obtains a value for the constant product of the velocity of the wind, and the barometrical gradient, which is 3000, a figure almost exactly double that (1400) given by Mohn in his 'Storm Atlas.'

In the 'Geographische Jahrbuch,' vol. iv., Dr. Hann gives a summary of the progress of Geographical Meteorology (a subject to which he has paid much attention) with a view to elucidate extra European climatology, especially that of the southern hemisphere. Dr. Hann notices all the recent papers and publications of importance bearing upon the subject. From his paper it appears that 739 stations use English, and 614 the metrical measures, while 114 use Paris inches and Reaumur's Thermometer Scale.

Commodore M. F. Maury, Honorary Member of this Society, in an Address delivered before the National Agricultural Congress at St. Louis in May, has again given utterance to his ideas and hopes regarding international "crop" telegraphy, which have been brought prominently before the public within the last two years, and with reference to which he addressed a memorial to the Statistical Congress at its Meeting in St. Petersburgh in August. He repeats his former arguments for the advisability of publishing information as to the weather, and the growth of crops in the diverse regions of the globe.

Mr. Buchan, Secretary of the Scottish Meteorological Society, in his Presidential Address to the Botanical Society of Edinburgh in November 1871, refers to the influence of climate on the growth of crops. He first discusses De Candolle's statement that "every species having its northern limit in Central or Northern Europe, advances as far as it finds a certain fixed amount of heat, calculated from that day of the year when a certain mean temperature commences, to the day when that mean temperature terminates." Thus Boussingault examined the distribution of wheat in Europe, and arrived at the conclusion that it required 8248° F., from the time it begins to grow in spring, for the proper ripening of the seed; and, moreover, that it must have a mean summer temperature of 58° F., during the development and maturing of the seed.

Mr. Buchan shows that wheat has ripened well in Scotland with a mean temperature of only 54°·4, and he attributes this partly to the greater length of days, inferring that it is not mean temperature alone, but daily range, which influences the result; and this is closely related to the rainfall and the amount of cloud.

The author then diverges into a discussion of the rainfall and prevailing winds in various regions of the globe, showing how the different types of climate are thereby produced, and concludes by a suggestion that local Natural-History Societies should publish charts of the distribution of species within their own districts, which would afterwards furnish materials for a complete investigation of the relation of climate to vegetation.

* *Vide* vol. iv. pp. 226, 353.

Dr. Hornstein, Director of the Observatory of Prague, has read a paper before the Vienna Academy on the Influence of the Electricity of the Sun on the level of the Barometer.

He says that more than thirty years ago Prof. v. Lamont attempted to explain the daily variations in Terrestrial Magnetism by supposing the sun to be electrical and capable of producing a certain electrical condition in the atmosphere. Later he was led to the same hypothesis by the daily oscillations of the barometer, which exhibit two maxima and two minima, like the tide. In the Annals of the Munich Observatory for 1859 he expresses his conviction that this atmospheric tide "is not any mathematical expression representing a portion of a complicated movement, but that it actually exists and is produced by the attraction or by some similar action of the sun." Subsequently Prof. Lamont has returned to this idea more than once, and hinted that the explanation was to be found in the electrical power of the sun, and in No. 28 of his 'Wochenbericht,' for January 1866, he gives his views on electricity and its cosmical importance as follows:—

1. Electricity is a cosmical force, possessed by all the planets in certain quantity, and by the Sun to a much larger extent.
2. The Sun is positively electrified, the Earth negatively.
3. The Earth has a nucleus capable of induction.

Dr. Hornstein thinks that the truth of Prof. Lamont's hypothesis would be established if he could discover a close relation between daily and other barometrical oscillations and the periods of sun-spots and the aurora.

He says that it is well known that the two latter phenomena exhibit, in addition to their period of $11\frac{1}{9}$ years, a longer period; and he shows by records, extending from the year 1740, that the number of years since that date is nearly equal to twice the longer period, which is, as he shows, 69·73 years, or 70 years. He suggests that perhaps the shorter period may be exactly one sixth of the longer.

He then proceeds to the treatment of the atmospheric tide, as exhibited in the observations for Prague and Munich extending to 1841, and for Oxford to 1858, and shows that the values of the annual coefficient for the atmospheric tide, contained in the hourly observations for Prague and Munich since 1841, can be very satisfactorily represented by the hypothesis that this coefficient follows, in common with the aurora and sun-spots, the longer (70-year) period, and that it has its maximum and minimum simultaneously with these phenomena.

Dr. Hornstein next proceeds to examine the annual fluctuation of the barometer, and he finds, from the records of Milan (1763–1850), Vienna (1775–1869), Prague (1800–1871), and Munich (1825–1866), that the same period of 70 years is unmistakably traceable, the curves of the four places corresponding closely with each other, and reproducing almost exactly the curve of sun-spot and aurora frequency.

The Journal of the Austrian Meteorological Society contains a paper by Dr. Hann, on the climate of Zanzibar, which is of special interest, now that attention is so much directed to that locality. The materials have mainly been obtained from the Journal of the Royal Geographical Society.

The most remarkable characteristics of the climate are the extreme insignificance of the variations of temperature and the all but constant saturation of the air. The range of temperature from the coldest to the warmest month is 6°·3 Fahr., the mean diurnal range 3°·6, and the variation between the mean absolute extremes is only 14°·4. The monthly amplitudes do not exceed 9°. The absolute maxima do not exceed 87°·8, and are lower than what are observed almost any summer during three months in Central Europe. The temperature cannot therefore be the cause of the unhealthiness of the climate of Zanzibar, which must be due to the uniform tropical heat combined with the saturation of the atmosphere, unless its cause is other than climate. The unhealthy season is after the rains, as in India. Colonel Sykes notes the absence of dew as a further characteristic of the climate, the nocturnal reduction of temperature being insufficient to produce condensation. Rigby, however, speaks of a heavy dew. The year is divided by the prevalent winds into two unequal portions; the wind blows from S.W. and E.S.E. for nine months, and from N.E. for the remainder. The N.E. monsoon sets in between the end of November and beginning of December, and blows with great force for two months, falling off or disappearing after the middle or end of February. The change to the S.W. monsoon in March or April is accompanied by violent storms and frequent showers, which are often confounded with the true rainy season (Burton). The S.W. monsoon, which, especially in the afternoon, blows frequently

from S.E., really an undiverted trade-wind (Burton), sets in between the end of March and middle of April, beginning on the southern part of the coast, and comes to an end in October or November.

Hurricanes and thunderstorms are rare at Zanzibar, though common on the mainland opposite. This contrast is like that which holds as regards thunderstorms at Cape Town.

The wet season at Zanzibar is double, and begins, as usually assumed, from four weeks to six weeks after the passage of the sun over the zenith on October the 9th and March the 4th. Rain, however, falls all through the year. June and July are the driest months.

Climate of Zanzibar. 6° 28′ S. lat., 39° 30′ E. long.

Month.	Temperature.					Humidity.	No. of Rainy Days.	Prevalent Direction of Wind.
	Mean of Max. and Min.	Daily Range.	Max. in Month.	Min. in Month.	Range in Month.			
	°	°	°	°	°			
December ...	81·7	3·2	...	...	...	94	...	N.E.
January	83·5	4·5	87·1	80·1	7·0	91	2	N.E.
February ...	83·5	5·4	88·0	79·0	9·0	87	1	N.E.
March.........	83·3	5·0	88·0	79·5	8·5	91	10	E., Var.
April	81·5	2·9	86·0	78·1	7·9	96	16	S., S.W.
May	78·6	2·0	82·9	73·6	9·3	99	15	S.W., S.S.W.
June	78·4	3·2	82·6	75·6	7·0	96	3	S.W., Var.
July	77·2	3·6	81·5	73·9	7·6	100	9	Var., S.W., S.S.E.
August	77·4	3·1	81·5	74·5	7·0	99	6	Var., S.W., S.S.E.
September ...	77·5	4·1	82·0	73·6	8·4	91	12	S.W., E.S.E.
October	79·2	4·0	82·9	75·0	7·9	91	15	S.W., E.S.E.
November ...	79·9	2·0	84·6	75·9	8·7	97	14	S.W., E.S.E.
Year	80·1	3·6	88·0	73·6	14·6	94·3		

Dr. Hann gives another short paper, in the same Journal, on the climate of two stations on the east coast of South America, Taquara, lat. 29° 40′ S., and Bahia Blanca, lat. 38° 43′ S., with tabular results of temperature, cloud, and rain. He remarks that these data show more clearly than before that the rainfall of the east coast of South America hardly exhibits a trace of the existence of a subtropical zone; in fact Bahia Blanca has a great preponderance of rain in summer and a minimum in winter, though it lies on the parallel corresponding to Lisbon and the Azores.

Herr Johann Molnár, of Pesth, who has for many years conducted meteorological observations in connexion with health at the Hospital of St. Roche in that city, has published in the Journal for Meteorology some hints on sanitary meteorology.

He is convinced that meteorological changes reflect themselves in the number of the sick. It is not, however, on the next day, but, according to the extent and duration of the meteorological oscillation, on the second and following days, that the results of the changes find their expression in an increased number of sick. From this he has been led to the conclusion that the main influence of the meteorological elements on the human organism is produced by their changes. Hence a comparison of the true means and the number of attacks of disease for a definite time will not easily throw light on the subject. He then gives instances to show how widely different observations may yet give the same means.

The author concludes by suggesting that meteorological observations should be taken from self-recording instruments which will exhibit sudden changes. The pathological phenomena for the day should be exhibited in parallel columns with these, and for each Meteorological element by itself. To this may be added daily observations on the intensity of light.

Herr Köppen has given in the Russian 'Repertorium für Meteorologie,' vol ii., a paper on the investigation into the sequence of the non-periodic phenomena of weather according to the doctrine of probabilities. An abstract of the discussion is given in the Journal for Meteorology.

One remark is applicable to the recent abnormal conditions of weather. " popular idea that a cold winter is usually succeeded by a hot summer and a v winter by a cold summer has no meteorological basis, as is shown both by Que and Eisenlohr."

At the Meeting of the British Association held at Brighton in August l paper was read "On a Periodicity in the frequency of Cyclones in the In Ocean, South of the Equator," by Mr. Meldrum.

The observations extend from 1847 to 1872, those for the first four y (1847–50) being more or less incomplete. It is found that in the area betwee equator and the parallel of 25° S., and the meridians of 40° and 110° E., years have been remarkable for a frequency, and others for a comparative ab of cyclones.

The five years 1847–51 were characterized by cyclone frequency; then ca period of comparative calm (1852–57), which was followed by six years (1858 remarkable for cyclones. The next five years (1864–68) showed a conside decrease, and since 1869 there has been an increase, until, for last year (187 to the end of June the number of cyclones was greater than in any year 1861. These years correspond very closely with the maxima and minima ep of sun-spots.

Mr. Meldrum considers that, to examine the matter fully, it would be nece not only to know the number of cyclones in each year, but also the extent and d tion of each and the force of the wind.

If an expression could be obtained for the annual amount of cyclonic energy, it could be shown that it varied directly as the amount of sun-spots, a conne would be established.

Mr. Meldrum then takes the maxima and minima epochs of the sun-spot pe and one year on each side of them, and by comparing the number of cyclon these three-year periods, obtains the following results:—

	Years.	No. of Cyclones in each year.	Total No. Cyclones
Maximum	1847	4	15
	1848	6	
	1849	5	
Minimum	1855	4	8
	1856	1	
	1857	3	
Maximum	1859	5	21
	1860	8	
	1861	8	
Minimum	1866	5	9
	1867	2	
	1868	2	
Maximum	1870	3	14
	1871	4	
	1872	7	

On a supposed Periodicity of the Rainfall. By Mr. C. Meldrum Reprinted from the Mauritius 'Commercial Gazette,' Oct. 16th, 18

At former Meetings of the Society I had the honour to endeavour to show the cyclones of the Indian Ocean, south of the Equator, have a periodicity responding very nearly, if not entirely, with the solar-spot period of eleven y a maximum amount of cyclone frequency having occurred in or about the y 1848 and 1860, and a minimum in or about the years 1856 and 1867; and I fu endeavoured to show that this law extends to the West-Indian cyclones.

With regard to the Indian Ocean, for which we have a large mass of info tion, embracing nearly twenty-five years, there is, I think, little doubt of a phy connexion between sun-spots and cyclones; but, still, it being desirable to tes theory, as far as possible, I have prepared some Rainfall Tables, with the vie finding whether they would give any indications of a similar periodicity.

It is well known that cyclones are generally accompanied with torrential r

The years therefore in which cyclones are most frequent should apparently be more rainy than the years in which they are less frequent. But to make this a fair test of the existence of a periodicity of cyclones in the Indian Ocean, it would be necessary to know the annual rainfall over the same area for the same length of time. If such rainfall had no periodicity we should have reason to doubt a cyclone-periodicity; but, if there was a similar rain-periodicity, it would, so far, be a confirmation of a cyclone-periodicity.

As we have no means of ascertaining the annual rainfall over the Indian Ocean generally, all that can be done is to examine the rainfall tables of land-stations in or near it; and for these we have, for a sufficiently long period, only the Mauritius tables, to which have been added for comparison, others from Adelaide and Brisbane.

Tables showing the yearly amount of Rainfall at Brisbane (Queensland), Adelaide (New South Wales), and Port Louis (Mauritius).

Brisbane.		Adelaide.		Port Louis.	
Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.
	inches.		inches.		inches.
1860	54·63	1839	19·840	1853	39·829
1861	69·44	1840	24·107	1854	39·435
1862	28·27	1841	17·956	1855	42·665
1863	68·82	1842	20·318	1856	46·230
1864	47·00	1843	17·192	1857	43·445
1865	24·11	1844	16·878	1858	35·506
1866	37·24	1845	18·830	1859	56·875
1867	61·04	1846	26·885	1860	45·166
1868	35·98	1847	27·613	1861	68·733
1869	54·36	1848	19·735	1862	28·397
1870	79·06	1849	25·444	1863	33·420
1871	45·45	1850	19·274	1864	24·147
		1851	30·633	1865	44·730
		1852	27·340	1866	20·571
		1853	26·995	1867	35·970
		1854	15·346	1868	64·180
		1855	23·145	1869	54·575
		1856	24·921	1870	45·575
		1857	21·156	1871	41·610
		1858	21·522		
		1859	14·842		
		1860	19·670		

Before discussing these Tables it will be convenient to mention that the years of minimum and maximum sun-spot frequency, and of corresponding cyclone-frequency, were:—

Minimum epochs .... 1844, 1856, 1867.
Maximum epochs................ 1848, 1860, 1871 (?).

Let us now examine the Rainfall Table for Port Louis, embracing nineteen years (1853–71). Taking the rainfall in each minimum and maximum epochal year, and in one year on each side of it, we get:—

	Years.	Rainfall.	Total Rainfall.
Minimum	1855	42·665	133·340
	1856	46·230	
	1857	43·445	
Maximum	1859	56·875	170·774
	1860	45·166	
	1861	68·733	
Minimum	1866	20·571	120·721
	1867	35·970	
	1868	64·180	

These figures show a marked excess of rainfall for the three years comprising the maximum sun-spot year (1860), which was also the year of maximum cyclone-frequency.

We do not know what will be the rainfall for 1872 and 1873; but, so far as can be judged at present, there is no reason to doubt that the next three-year period will give a favourable result.

If, in place of one year, we take two years on each side of the epochs, we shall get:—

	Years.	Rainfall.	Total Rainfall.
Minimum	1854	39·435	207·281
	1855	42·665	
	1856	46·230	
	1857	43·445	
	1858	35·506	
Maximum	1858	35·506	234·677
	1859	56·875	
	1860	45·166	
	1861	68·733	
	1862	28·397	
Minimum	1865	44·730	220·026
	1866	20·571	
	1867	35·970	
	1868	64·180	
	1869	54·575	

Here, again, we have a *similar* result. It is not so well marked as the former, but this may be partly owing to the rain-gauge having been removed in November 1866, from the Old Observatory to a temporary one in Little Moutain Street, where the rainfall was probably somewhat greater.

So far, then, as the Port Louis observations enable us to judge, it may be said that, during the last twenty years, there has been a rainfall-periodicity corresponding with the cyclone-periodicity in the Indian Ocean, south of the Equator.

This may be considered as confirmatory of the correctness of the cyclone period; for if the rainfall at one station shows a corresponding periodicity, much more should a mean of the rainfall at many stations within the whole cyclonic area do so.

Although Adelaide and Brisbane are a long way outside the area for which the cyclone period was determined, yet it is curious to see that there also the rainfall tables seem to point to a similar periodicity.

From Adelaide (lat. 34° 56′ S., long. 138° 38′ E.) we have twenty-two years' observations made by Mr. George Strickland Kingston, and, treating them as above, we get:—

	Years.	Rainfall.	Total Rainfall.
Minimum	1843	17·192	52·900
	1844	16·878	
	1845	18·830	
Maximum	1847	27·613	72·792
	1848	19·735	
	1849	25·444	
Minimum	1855	23·145	69·222
	1856	24·921	
	1857	21·156	

By taking five-year periods we get:—

Minimum	=100·076 inches.
Maximum	=118·951 "
Minimum	=106·090 "

These results are all similar to those obtained from the Port Louis observations; but, as the Adelaide rainfall for 1859 and 1860 was small, it may be doubted whether the next maximum period gave a favourable result at that station.

From Brisbane (lat. 27° 28′ 3″ S., long. 153° 6′ 15″ E.) we have twelve years'

rvations, for which we are indebted to Mr. Edmund MacDonnell. Comparing ı with the Mauritius observations for the same period, we cannot but be struck ı a resemblance, which comes out still more forcibly when we take three-year ›ds, thus:—

Years.	Port Louis.		Brisbane.	
1860	45·166		54·63	
1861	68·733	142·296	69·44	152·34
1862	28·397		28·27	
1863	33·420		68·82	
1864	24·147	102·297	47·00	139·93
1865	44·730		24·11	
1866	20·571		37·24	
1867	35·970	120·721	61·04	134·26
1868	64·180		35·98	
1869	54·575		54·36	
1870	45·575	141·760	79·06	178·87
1871	14·610		45·45	

/e see that at both stations the epoch of minimum rainfall is coincident, or ly so, with the epoch of minimum amount of cyclones, which is itself coinci- ; with the minimum amount of sun-spots; and that at, or near, the maximum ın-spots and cyclones, we have also a maximum amount of rainfall.

rom what has been said, it will, I think, be admitted that at least a case of *osed* periodicity of rainfall has been made out, and that it is highly desirable the matter should be further investigated. This can be done chiefly by long- inued observation under the same conditions as to locality, size of gauge, &c., perhaps to some extent by ascertaining, if not the actual rainfall, at least the ; remarkable for the comparative absence or abundance of rain in former s.

should be remarked that some localities are probably much more favourable others for showing the operation of a general law of this kind; for there may cal causes affecting the rainfall so powerfully as to completely mask the effect weaker but more general cause; and therefore it would be no proof of the existence of a connexion between rainfall and sun-spots to show that the vations taken at such and such places were not in conformity with the sup- l periodicity.

e should be inclined to think that the best mode of testing the matter would obtain records of observations carefully made for a long period in some of the ds of the Indian and Pacific Oceans, for example, far removed from the dis- ng influence of Continents, and then to take a mean of all the observations.

.e Adelaide and Brisbane observations would seem to indicate a rainfall- dicity altogether independent of a cyclone-periodicity, both being apparently ıatural consequences of one and the same law. But it would be rash to say at present, and I should wish it to be understood that the object of this r is simply to stimulate further inquiry.

[E METEOROLOGICAL CONFERENCE AT LEIPZIG.—The French Meteorologists taken up the subject of this Conference, of which a report in English will ly appear, and in the 'Bulletin Mensuel' of the Montsouris Observatory for ıst last they have proposed a number of questions, which, in the opinion of the ng Committe, may be reprinted in this Journal, in order to place in the hands e Fellows an account of the progress of Meteorology over the globe.

n addition to the questions inserted in the *invitation* to the preparatory Congress eipzig, others may be added, more specially relating to the climatology of ce, and to the prosecution of the science as applied to agriculture.

Is it expedient to establish in each agricultural or maritime region a more perfect observatory, charged with observations destined for international publication? What subjects should be specially studied at these establish- ments? With what instruments should they be supplied?

II. Is it expedient to establish in each department a departmental meteorological observatory? What subjects should be specially studied at these establishments? With what instruments should they be supplied? At what hours should the daily observations be made?

III. Is it expedient to encourage the establishment, in each department, of volunteer meteorological stations, with the view of diffusing the taste for meteorological observations, and their application to the wants of modern society? What subjects should be specially studied? What should be their number and distribution, as they would have to record temperature, rainfall, thunderstorms, and the phases of vegetation?

IV. Is it expedient to place these works on generally uniform bases? What should these bases be for each class of study?

V. How can the discussion of these observations and their publication be guaranteed? In this work of the discussion and publication what should be the part of the department and the departmental commission, of the learned societies of the department, of the central establishment and the State, and of the international service?

VI. What measures should be taken in order that the partial or general results comprised in the different international, national, or departmental publications may be within the reach of persons desirous of consulting them?

VII. Is it expedient to give a fresh impulse to the preparation of physical and statistical atlases for the whole of France, and for each department in particular?

VIII. These atlases, being designed to sum up for the public all the works that give information about the soil of our country, its resources of every kind, the part which is turned to advantage and that which might be turned to advantage, is it expedient to undertake them on a uniform basis, which should at the same time make these departmental atlases a noticeable feature of our country.

IX. What means would it be expedient to adopt in order that all the men of science could assist in preserving the benefit of their work?

X. What part in the execution of the work ought to be borne by the departmental and central institutions, by the different learned societies, and by the public?

XI. Is it expedient to undertake and to continue this great work only with the resources which are, or can be, furnished by the State, by the departments and by the learned societies, or to interest the public by subscriptions, either for the atlas for the whole of France, or at the same time for all the atlases of France and the departments?"

Donations received from November 1st to December 31st, 1872.

Presented by Societies, Institutions, &c.

Brisbane	Observatory	Summary of Meteorological Observations, January to June 1872.
	"	Summaries of Rainfall throughout the Colony, December 1871 to June 1872.
	"	Summary of Observations at Warwick, October 1871 to March 1872.
	"	Ditto at Sweer's Island, July to December 1871.
	"	Ditto at Toowoomba, January to March 1872.
	"	Ditto at Ravenswood, October 1871 to March 1872.
	"	Ditto at Cape Moreton, October to December 1872. By E. MacDonnell, Government Meteorological Observer.
Brussels	Observatoire Royal	Annales, October 1871. By M. A. Quetelet, Director.
Cracow	K. K. Sternwarte	Meteorologische Beobachtungen, October 1872. By Dr. F. Karlinski, Director.
Geneva	Société de Géographie	Le Globe, tome xi., livraisons 1–3, 1872.
London	Admiralty	Wind and Current Charts for Pacific, Atlantic, and Indian Oceans. By Rear-Admiral Richards, C.B., F.R.S., Hydrographer.
	London Institution	Journal, No. 17.
	Meteorological Office	Daily Weather Report and Charts.
	"	Quarterly Weather Report, 1872. Part i. By the Meteorological Committee.
	Royal Society	Proceedings, No. 138.
Manchester	Literary and Philosophical Society.	Proceedings, October 1st to December 10th, 1872.
Newcastle	Tyneside Naturalists' Field Club.	Meteorological Report for 1871. By Rev. R. F. Wheeler, M.A.
New York	Observatory	Annual Report of the Director, 1871. By Daniel Draper, Director.
Paris	Observatoire National	Bulletin International.
	" "	Bulletin Mensuel, October and November 1872.
	Société Météorologique de France.	Annuaires, 1869, feuilles 19–27; 1870, feuilles 1–8; 1871, feuilles 1–9.
Rome	Osservatorio del Collegio Romano.	Bullettino Meteorologico, vol. xi. nos. 10–11. By Padre A. Secchi, Director.
St. Petersburg	Central Physical Observatory.	Annalen, 1870. By H. Wild, Director.
Stockholm	Royal Swedish Academy of Science.	Meteorologiska Jakttagelser i Sverige, 1870. By Prof. Er. Edlund.
Sydney	Observatory	Return of monthly Meteorological Results from daily observations at the Government Observatory, Sydney, in the year 1867.
	"	Monthly and annual means of the observations taken daily at the several stations in New South Wales during 1868.
	"	Monthly Meteorological Observations made at the Government Observatory, Sydney, September 1869, July and August 1872. By H. C. Russell, B.A., Government Astronomer.

Toronto	Education Office	Journal of Education, July to October 1872. By Rev. E. Ryerson, D.D.
Vienna............	K. K. Centralanstalt für Meteorologie und Erdmagnetismus.	Beobachtungen, October 1872. By Dr. C. Jelinek.
Washington ...	War Department	Tri-daily Weather Maps and Bulletins, Nov. 8th, 1872. By Brigadier-General Myer, U.S.A., Chief Signal-Officer.

Presented by Individuals.

Bianconi, G. Antonio	Sul Clima d'Europa all'epoca glaciale considerazioni del dott. Gian Antonio Bianconi.
Birt, W. R., F.R.A.S.	A Contribution to our knowledge of Atmospheric Waves.
Chase, P. E.	Cyclical Rainfall at San Francisco.
"	Lunar-cyclical Rainfall in the Northern Temperate Zone.
"	Recent Monthly Rainfall in the United States.
Greaves, Charles	British Association Reports, 1831-37, 1841-48.
Higgs, Rev. W., M.A.	'Telegraphic Journal,' vol. i. No. 1.
Prettner, Dr. J.	Meteorologische Beobachtungen zu Klagenfurt, October 1872.
Scott, R. H., M.A., F.R.S....	Winds and their courses: or a practical exposition of the laws which govern the movements of hurricanes and gales. By G. Jinman, Master Mariner.
The Editor	'Food Journal,' Nos. 34-35.
"	'Nature,' Nos. 157-159, 161-165.

QUARTERLY JOURNAL

OF

IE METEOROLOGICAL SOCIETY.

.. I. No. 6.

I. *Solar Radiation.—An account of some Experiments made at Harpenden, Herts.* By the Rev. Fenwick W. Stow, M.A., F.M.S.

[Received December 18, 1872. Read January 15, 1873.]

E chief object of these experiments was to ascertain approximately the ts of error in the plan for measuring Solar Radiation which the author previously submitted to the Society. He then proposed to expose ly to the sun and air, at 4 feet above the ground, a thermometer *in vacuo*, 1 the bulb and 1 inch of the stem blackened, the bulb being directed to south-east, and to consider the excess of its readings above those of an inary thermometer in the shade, at the same height from the ground, to he amount of solar radiation. Observations on this plan have been re-ed from about a dozen stations.

'he experiments consisted partly in a comparison of the measure of r intensity thus furnished with those obtained by a Herschel's nometer, and by other means, and partly of experiments with similar of different thermometers exposed under different conditions, in order hrow some light on the question what the words "Sun" and "Shade" ald be held to mean, at least for the purpose of measuring solar radia-L. The latter are detailed in a separate paper.

n Table I. the results of comparison with the Herschel's actinometer given. The observations were taken towards the end of September, 2, when the weather was not at all favourable for the purpose, there ig very little steady sunshine; while the rapid fluctuations in the of cooling, caused by fitful breezes, rendered the change per minute r uncertain when the actinometer was used with the glass off. It is btful whether the use of a fluid so variable in its dilatability as ammo-o-sulphate of copper is desirable; nor is it likely that the inclosed ther-neter shows the mean temperature of the whole liquid at the moment

of observation with any approach to exactness; and yet an error of [illegible]° will generally make an error of 2 per cent. in the corrected results. Probably the actinometers invented by Mr. Hodgkinson, and described in the 'Proceedings of the Royal Society,' vol. xv. p. 321, are more satisfactory, since alcohol is the fluid used. The author had experienced also some difficulty in shading the instrument, without altering the conditions of cooling from those which existed during its exposure to the sun; but in the face of these difficulties it is satisfactory to find that the ratio between the indications of the two instruments fluctuated, on an average, less than 2 per cent. for the higher numbers, and 3 per cent. throughout, except in the case of observations taken when the sun was just setting. This is the more satisfactory, because the blackened bulb *in vacuo* receives the heat reflected from the clouds on all sides, whereas the actinometer can, from its construction, admit only what comes from clouds near the sun; and variations in the indications of the two instruments are necessarily thus introduced according as the state of the sky changes.

It seems therefore that whenever a standard unit of solar intensity exists, observations made according to this method, with the blackened bulb *in vacuo* at 4 feet above the ground, or at whatever height the shade thermometers are placed, will give results reducible to such units.

But, putting an absolute standard, such as that obtained by the melting of ice, out of the question, he thought that the total elevation of temperature which a blackened bulb *in vacuo* experiences above the temperature of its surroundings, before equilibrium is established between the heating energy of the solar rays and the forces which tend to cool the bulb, is a better measure of radiation, and more suitable for a standard than the rise per minute of a liquid in a tube. He was not, however, prepared at present to say how such a standard should be made. Possibly an apparatus like Padre Secchi's, but larger and mounted equatorially, might be advisable, the sun's rays being admitted through a piece of rock-salt, or other crystal, and as perfect a vacuum as possible obtained inside.

He must here express his thanks to Mr. Wilson for assistance in taking the observations, to Mr. Eaton for giving the benefit of his experience in the use of actinometers, and to Mr. Nunes* for help in some of the experiments, and for the loan of the instruments.

He might also briefly mention that he tried a Pouillet's pyrheliometer; but its extreme sluggishness, which renders a long exposure necessary, demands steady and long-continued sunshine. He was unable therefore to compare it satisfactorily with any other instrument.

Another measure of solar radiation might be obtained by the blackened bulb *in vacuo*, by taking the excess of its readings above those given by a bright unblackened bulb, also *in vacuo*. This plan would have the important advantage for ordinary registration of securing that the maxima shown by the two instruments should be simultaneous, which is not generally the case when the maximum shade-temperature is employed. The maximum in the sun generally occurs soon after noon; that in the

* This was written before Mr. Nunes's lamented death.

shade at least an hour later. Nevertheless it will be seen by a comparison of the two methods, made at Hawsker in 1871 (Table II.), that the ratio of the numbers obtained by the two methods was found nearly constant, except in very cloudy weather.

Nearly all the blackened-bulb thermometers *in vacuo* used by the author's correspondents have been compared with his own in the sun. Of these, two agree exactly with his own, five more within 1°, three within 2°; but one reads 4°·5 in excess, when the amount of solar radiation is 50° by his instrument. It is certainly necessary to compare them in the sun. The lampblack is generally applied with a varnish, and sufficient care is not always taken to have the bulb perfectly dull; imperfections in the vacuum sometimes occur, and differences in the thickness of the glass are inevitable. Another fact has generally been overlooked, viz. that the index-error is altered by the removal of atmospheric pressure, most of these instruments reading 0°·5 too low. In some careful experiments by Mr. Benjamin Loewy, F.R.A.S. (reported, vol. xvii. p. 319 of the 'Proceedings of the Royal Society'), the behaviour of thermometers in a vacuum was investigated. It was found that although the immediate effect of exhaustion diminished after a time, the reading of a thermometer in a vacuum was permanently depressed, and further, that thermometers with small bulbs were more affected than those with larger bulbs, because the glass was thinner. It would be well if solar thermometers were compared at Kew, both in the sun and in water, after enclosure and exhaustion.

Mr. Nunes had proposed to admit dry air into the jackets of these instruments. The indications are thereby rendered less sensitive, since the point of equilibrium is very much lowered by the rapid cooling consequent on the presence of air. Errors arising from the use of instruments with vacua of different degrees of imperfection are got rid of; but, on the other hand, a pressure depending on temperature is introduced.

Table III. contains a comparison of the two kinds of instruments. Mr. Nunes had a pair of thermometers specially constructed by Mr. Casella, with very large bulbs (0·6 inch diam.). They were similar in every respect, except that chemically dried air was admitted into the glass jacket of one of them. These were compared with a pair similarly made by the same maker, but with bulbs of half the diameter; and Mr. Pastorelli supplied a pair of dry-air instruments, one having a bulb about 0·35 inch diam., and the other 0·5 inch. Days on which the sunshine was pretty steady were selected, to eliminate as far as possible the great difference in the sensibility of large and small bulbs. It will be seen that the two thermometers *in vacuo* both agreed more closely, and exhibited fewer irregularities, than the dry-air instruments. The blackened bulb, being much hotter than the enclosed air, imparts to it a quantity of heat depending upon its own size and the volume of the enclosed air; and if this air be hotter, the temperature which the bulb attains in the sun will evidently be higher. A larger bulb or smaller jacket will therefore cause a higher temperature to be indicated. This is exactly what was found to be the case. The large bulb,

in dry air, by both makers gave a higher reading than the small bulb; but, as the jackets of Pastorelli's thermometers were smaller, each of these instruments read higher than the corresponding one of Casella's. (See Table IV.)

In the case of thermometers *in vacuo*, when the unequal loss of heat by conduction is got rid of by extending the lampblack to the stem, the only remaining sources of error are the mere accidents or imperfections of construction. True, considerable differences are sometimes observed in the indications of these instruments; but these are exceptional, and in any case it is easy to compare the instruments and allow for them.

Table V. shows the results obtained by exposing a blackened bulb to the sun's rays under the exhausted receiver of an air-pump. The bulb of the instrument was placed about 2 inches from the top of the receiver, and observations were taken on two days. On the second day the apparatus had been exposed for some time to the sun before the observations were made, and the plate on which the receiver rests had become heated, which may account for the readings being relatively higher. But, in spite of the diversity of conditions, including a considerable difference in the thickness of the glass, there was a near approximation between the indications of this instrument and those of a solar thermometer of the ordinary construction.

It would be an improvement to have an attached or inserted thermometer, contrived to show the temperature of the outer jacket, and to use this, or the reading of a thermometer *in vacuo* with unblackened or, still better, silvered bulb exposed to the sun's rays, instead of the temperature of the air in the shade. But, even as it is, observations made on the system suggested four years ago are scarcely, if at all, inferior to observations taken with a Herschel's actinometer, and valuable results might surely therefore be thus obtained.

To look at the subject generally, there are three different objects which meteorologists may propose to themselves in attempting to measure the sun's heat. The first is the measurement of the intensity of the solar rays, irrespectively of the duration of sunshine and of the angle at which the rays strike the ground. The second is the total heating effect upon a large mass of earth, metal, or water, also irrespectively of the angle of incidence of the sun's rays, but depending both upon the intensity and the duration of the sunshine. This might be measured by inserting a thermometer into the centre of a hollow sphere, such as a 68-lb. shell, which might be filled with water, and should be elevated above the ground. The third is the heating effect produced upon the earth's surface, depending upon the altitude of the sun, as well as upon intensity and duration of sunshine, not to mention moisture, evaporation, &c. This may be measured by a thermometer, not *in vacuo*, placed upon the ground, or still better perhaps, by one buried just below the surface of a level sand-bed.

It is to the first of these, Actinometry, that he has directed attention. The author does not say that the other investigations are not equally important; but he thinks it best to obtain figures which represent the

action, not of a variety of causes, the individual effect of each of which is unknown, but of one cause only, and afterwards to proceed to the investigation of the effects of two or more causes combined. Thus, supposing that a measure of solar radiation or intensity is first obtained, and then results involving both intensity and duration discussed. These being both known, the third investigation might be approached where the sun's altitude and other causes are also involved. It might be even worth while to attack the complication of causes to which the temperature of a black bulb *in vacuo* on the grass is due. But the present system is to jumble together every species of heterogeneous observations depending upon all possible causes, known or unknown, and to call these by the one name of the "maximum in the sun." It is to be hoped that if this Society is to have any thing to do with publishing meteorological observations, it will not sanction any such chaotic arrangements, but insist on a uniform system of meteorological observations of all kinds, and not publish those taken on a different system.

It is not known that the heat emitted from the sun is constant in amount. Very possibly it is not, but has a secular variation. This will be one of the most interesting points to be determined. A cycle corresponding to the eleven years' sun-spot period has been thought to appear in the Oxford observations of solar radiation. With more strictly actinometrical observations this question will easily be determined. The further question, however, will remain, whether such periodicity is due to more heat being emitted from the sun, or to less being intercepted by the atmosphere. Scarcely any thing is known as yet about the absorption of the sun's heat by the atmosphere. From the intensity of solar radiation on high mountains it may be concluded that the percentage absorbed, especially by the moist cloud-stratum, is very large. It is certainly subject also to extensive fluctuations.

The amount of solar radiation often varies inversely as the temperature of the air, a fact which seems to lie at the very root and starting-point of meteorology. If the Society would practically take up solar-radiation investigations it might hope to find the key to many unsolved problems. Good observations should be made and thoroughly discussed. In conclusion, the author will be more than content if he has succeeded in pointing out the means by which, in any one particular, valuable observations may be made.

TABLE I. Comparison of Actinometer with "Blackened-bulb Thermometer *in vacuo*" or Solar Thermometer.

Date, 1872.	Time.	Sun ⊙, or shade ×.	Actinometer.					Solar Thermometer.		
			Initial reading.	Terminal reading.	Temp. of liquid.	Sun's effect per min.	Ditto reduced to 60° F.	Reading at time in sun's rays.	Temp. of air in shade.	Diff. = amount of radiation.
Sept.	h m s				°			°	°	°
16	3 59	×	67·5	57·5						
		⊙	58	74	78	26	19·7	98	62·8	35·2
19	23 58 30	×	27·2	28	77					
20	Noon.	⊙	41	80		37·2	38·9	106·5[a]	50	56·5
,,	0 1 30	×	88·5	91·2	59					
,,	0 4	⊙	28	63·2	60	35·4	35·4	108	50	58
,,	0 6 30	×	44	41	...					
,,	0 8	⊙	4·8	41		39·2	37·7			
,,	0 9 30	×	46	43	63	...	...	109·5	50·5	59
,,	0 12	⊙	43	76·5	63·5	37·5	34·9			
,,	0 13 30	×	82	78	64	...	...	111·5[b]	51	60·5
,,	0 45	×	28·5	21·5	...					
,,	0 46 30	⊙	29·2	57·5	65	35·4	32·1	105	52	53
,,	0 49	×	53·8	46·5	...					
,,	1 4[c]	×	22·5	14	65					
,,	1 6 30	⊙	40	63·5	66	32	28·5	103·5	51·5	52
,,	1 8	×	65	56·5	...	...	...	104	52·5	51·5
,,	1 9 30	⊙	61·5	84	...	31·7	27·8	105	52·8	52·2
,,	1 12	×	25	15	67·5					
,,	1 16	×	33·5	25	66·5					
,,	1 18	⊙	25	48·2	...	31·9	28	107	52·8	54·2
,,	1 19 30	×	48	39	67·5					
,,	1 21[c]	⊙	41	67	68	35	30·1	108·2	53·3	54·9
,,	2 41 30	×	34·5	4·5						
,,	2 43	⊙	37·8	41·5	77	32·3	25·0	97·5	53·3	44·2
,,	2 45	×	75·5	48·2	76					
,,	3 25	×	32	25·3						
,,	3 26 30	⊙	28·5	40·5	63	18·7	17·6	81·5	51	30·5
,,	3 31	×	49·5	41·4						
,,	3 34	⊙	59·7	73	64	21·5	20			
,,	3 35 30	×	73·5	65·3	...	...	...	81	51·2	29·8
,,	3 38	⊙	61	75·8	...	23	21·4	84	51·5	32·5
,,	3 40 30	⊙	32·8	47·5	64	23·7	22	86·5	51·5	35
,,	3 42	×	47	38						
,,	3 43 30	⊙	41·8	57·8	64	24·4	22·7	88	51·8	36·2
,,	3 46	×	55	47·2						
,,	3 47 30	⊙	47·8	63·8	64	23·7	22	89	52·2	36·8
,,	3 49	×	64·5	57						
,,	3 52	⊙	52·2	67·2	...	22·8	21·2	89·5[d]	52·2	37·3
,,	3 54	×	72·5	64·5	64·5					
,,	3 55 30	⊙	64·5	79·5						
,,	5 4	×	28	22·8	60					
,,	5 5 30	⊙	22·5	25·2	...	8·8	8·8	66	49·3	16·7
,,	5 7	×	23·5	16·5	60					
,,	5 8 30	⊙	16·5	18	...	8·7	8·7	65	49	16
,,	5 10	×	16·5	9·1	59·5					
,,	22 38	×	50	54·5	55					
,,	22 39 30	⊙	66	99	...	28·5	30·8	101[a]	52·2	48·8
,,	22 42 30	×	10·3	13	58					
,,	22 44	⊙	27	65	...	35·9	36·6	105·5[a]	53	52·5
,,	22 45 30	×	72	73·5	...	...	...	106·5[a]	53	53·5
,,	22 47	⊙	10·8	48·2	60·5	36·2	35·9	108·5	54	54·5
,,	22 48 30	×	12·8	13·8	...	...	...	109·5	54	55·5
,,	22 50	⊙	22·2	41·5[f]	...	37·6	37	111·2	54	57·2
22	20 23	×	52·8	56·6						
,,	20 24 30	⊙	66	92·5	59	24·4	24·9	90	44·5	45·5
,,	20 26	×	49	49·4						

[a] Solar thermometer still rising. [b] Cloud very near to the sun.
[c] From $1^h\ 4^m$ to $1^h\ 21^m$ sun shining through haze and cirrus.
[d] *Registered* maximum. [f] Exposed only 30 seconds.

TABLE I. (*continued*).

Date, 1872.	Time.	Sun ☉, or shade ×.	Actinometer. Initial reading.	Actinometer. Terminal reading.	Actinometer. Temp. of liquid.	Actinometer. Sun's effect per min.	Actinometer. Ditto reduced to 60° F.	Solar Thermometer. Reading at time in sun's rays.	Solar Thermometer. Temp. of air in shade.	Solar Thermometer. Diff. = amount of radiation.
Sept.	h m s				°			°	°	°
22	20 28	☉	31	57·2	...	26·4	26·4	91	45·2	45·8
"	20 29 30	×	62	61·2	61					
24	20 3	☉	65	86·3	57	24·1	25·7	83·5	43·5	40
"	20 4 30	×	91	88·2						
28	21 15	☉	28	58	65	31·5	28·6			
"	21 16 30	×	66	64·5	...	...	...	101	56	45
"	21 18	☉	39	66	67	31·5	28			
"	21 19 30	×	88	83·5	...	...	...	101·2	56·2	45
Oct.										
6	23 50	×	51·2	60·6	55					
"	23 51 30	☉	27·7	64·1	58	27·7	28·9	104·8	57·2	47·6
"	23 54 30	×	26.5	34·6	59	...	...	105	58	47
"	23 56	☉	50·5	86·5	61	29·2	28·6			
"	23 58	×	38·5	44	61·5					
7	0 8	☉	29·5	61·5	67	34·2	29·9			
"	0 9 30	×	65·2	63	...	...	...	106·2	58·4	47·8
"	0 11 30	☉	31	60·6	68	32·1	27·7			
"	0 13	×	66·3	63·4	68·5	...				
"	0 14 50	☉	16·5	46·4	69·5	33·6	28·4	106·8		
"	0 16 30	×	21	16·5	70	...	...	...	58·4	48·4

TABLE I B. Comparable Observations arranged according to the Intensity of Solar Radiation by Actinometer.

Date.	Time.	Actinometer. Sun's effect reduced to 60° F. A.	Solar thermometer. Solar thermometer at time.	Solar thermometer. Temp. of air in shade.	Solar thermometer. Diff. = amount of radiation. B.	Ratio. $\frac{A}{B}$.	Actinometer. Mean sun's effect.	Solar thermometer. Mean amount of radiation.	Mean ratio. $\frac{A}{B}$.	Average departure from mean ratio.
Sept.	h m		°	°	°			°		
20	22 50	37	111·2	54	57·2	·65				
"	0 9	36·3	109·5	50·5	59	·62				
"	22 47	35·9	109	54	55	·65	35·3	56·4	·628	·018
"	0 4	35·4	108	50	58	·61				
"	0 46	32·1	105	52	53	·61				
Oct.										
7	0 8	29·9	106·2	58·4	47·8	·62				
6	23 51	28·9	104·8	57·2	47·6	·61				
Sept.										
28	21 15	28·6	101	56	45	·64	28·9	47·2	·614	·013
Oct.										
6	23 56	28·6	105	58	47	·61				
7	0 15	28·4	106·8	58·4	48·4	·59				
Sept.										
28	21 18	28	101·2	56·2	45	·62				
22	20 28	26·4	91	45·2	45·8	·58				
24	20 3	25·7	83·5	43·5	40	·64	25·6	42·2	·608	·026
20	2 43	25	97·5	53·5	44·2	·57				
"	3 44	22·7	88	51·8	36·2	·63				
"	3 48	22	89	52·2	36·8	·60				
"	3 40	22	86·5	51·5	35	·63				
"	3 38	21·4	84	51·5	32·5	·65	20·5	34	·604	·029
16	3 59	19·7	98	62·8	35·2	·56				
20	3 26	17·6	81·5	51	30·5	·58				
"	5 5	8·8	66	49·3	16·7	·53				
"	5 8	8·7	65	49	16	·54				

TABLE II. Comparison of difference of Blackened and Bright Bulbs *in vacuo* with difference of Blackened Bulb *in vacuo* and Air-temperature from observations made at Hawsker, near Whitby, 1871.

Date.	Maxima. Shade temp. a	Maxima. Bright b. in vac. b	Maxima. Black b. in vac. c	$c-b$.	$c-a$.	Ratio. $\frac{c-b}{c-a}$.
	°	°	°	°	°	
June 25	54·9	75	123	48	68·1	·70
" 21	54·1	74	120	46	65·9	·70
" 13	59·2	78·1	123·8	45·7	64·6	·71
" 22	54·3	74·5	120	45·5	65·7	·69
" 11	55	74	118·2	44·2	63·2	·70
" 4	52·5	72	116	44	63·5	·69
" 1	53·6	73	117	44	63·4	·69
" 3	50·2	69·2	112·2	43	62	·69
July 20	62	81	124	43	62	·69
June 5	53·5	74·3	117·2	42·9	63·7	·67
July 23	65	85	127·5	42·5	62·5	·70
June 2	49·8	67·2	108·8	41·6	59	·71
" 24	54·4	71·5	113	41·5	58·6	·71
Aug. 6	67·7	86·8	127·8	41	60·1	·68
May 26	61	78	119	41	58	·71
June 18	66·2	84·5	125·3	40·8	59·1	·72
May 25	65·6	79·2	120	40·8	54·4	·75
July 25	62·2	83	123·5	40·5	61·3	·66
" 1	67·7	83·2	123·5	40·3	55·8	·72
May 30	63·9	81	121·2	40·2	57·3	·70
July 30	63·3	82	122	40	58·7	·68
Aug. 21	65·2	82·2	122·2	40	57	·70
June 27	62·6	78·8	118·8	40	56·2	·71
July 22	66·5	85	124·8	39·8	58·3	·68
May 29	54·8	72·7	112·5	39·8	57·7	·69
" 24	62·5	78·2	118	39·8	55·5	·72
July 31	65	84	123·5	39·5	58·5	·68
Aug. 2	70·8	89·8	129·2	39·4	58·4	·68
" 25	64·2	81	120	39	55·8	·70
July 28	64·2	83·2	121·8	38·6	57·6	·67
May 23	57	74·5	113	38·5	56	·69
June 30	66	81	119·2	38·2	53·2	·71
Aug. 14	68·1	84	122·2	38·2	54·1	·71
" 22	63·4	79	117·1	38·1	53·7	·71
" 16	65	82	120	38	55	·69
July 26	62	75·5	113	37·5	51	·74
Aug. 26	64	80	117	37	53	·70
July 29	62·8	79·8	116·8	37	54	·69
May 21	65	81	118	37	53	·70
Aug. 1	67·8	83	120	37	52·2	·71
" 19	64	80·5	117	36·5	53	·69
" 13	67	84	120·5	36·5	53·5	·68
May 27	54·8	70	106	36	51·2	·70
Aug. 15	64·5	80	115·5	35·5	51	·69
" 11	81·2	96	131·2	35·2	50	·70
July 27	65·2	83	118·2	35·2	53	·66
Aug. 9	73	89	124	35	51	·69
" 8	69·4	86·8	121·5	34·7	51·5	·67
" 18	69	86	120·5	34·5	51·5	·67
July 21	64	76	106·5	30·5	42·5	·72
May 31	54·6	66	95·2	29·2	40·6	·72
Aug. 12	77·8	92	121·8	28·8	44	·65
June 19	61	72·5	101	28·5	40	·71
Aug. 23	66·1	77	104·5	27·5	38·4	·72
June 8	49·3	60	86·2	26·2	36·9	·71
Aug. 17	65	72	95	23	30	·77
May 28	50·9	59	79	20	28·1	·71
Aug. 20	65	72	92	20	27	·74
Sept. 18	52	58	77	19	25	·76
June 20	54·9	58·8	71·2	13·4	16·3	·82
Sept. 13	56	60	72	12	16	·75
" 12	57·2	61	70·5	9·5	13·3	·71
" 9	58·6	60	69	9	10·4	·86

TABLE III. Thermometers in Dry Air and *in vacuo*.

te, '2.	Days of steady sunshine.					
	Large bulb *in vacuo*. L.	Small bulb *in vacuo*. S.	Diff. L−S.	Large bulb in air. L′.	Small bulb in air. S′.	Diff. L′−S′.
of bulb ...	0·6	0·3	...	0·6	0·3	
of jacket...	2·33	2·2	...	2·32	2·26	
	°	°	°	°	°	°
....	137·5	136	1·5	121·7	116·8	4·9
....	116·8	116	0·8	102·7	101·3	1·4
....	130·6	130	0·6	115·2	111·8	3·4
....	127·5	126·1	1·4	111·5	106·8	4·7
....	125·6	125·5	0·1	111·2	106·9	4·3
....	129·1	128	1·1	114·2	110·6	3·6
....	130·6	129·2	1·4	117	111·8	5·2
....	138·4	137	1·4	124	119·3	4·7
....	126·8	126·2	0·6	116·2	113	3·2
....	131·7	131	0·7	118·2	113·8	4·4
....	135·1	134·2	0·9	122·7	118·3	4·4
....	134·6	133·2	1·4	123·7	120·8	2·9
....	128·6	128·2	0·4	117·2	113·8	3·4
....	125·1	124	1·1	108	103·8	4·2
....	129·6	128	1·6	113	107·8	5·2
....	122·6	122	0·6	107·2	104·8	2·4
....	123·6	121·5	2·1	112·2	107	5·2
....	129·6	126·8	2·8	115·2	110·3	4·9
....	128·6	126·5	2·1	114·2	109·3	4·9
....	135·8	134·2	1·6	120·2	115·8	4·4
....	129·39	128·18	1·21	115·27	111·19	4·08
viation an......	...	...	·52	...	...	·83

V. Comparison of four Blackened-bulb Thermometers in Glass Jackets containing Dry Air.

Date.	Casella.	Casella.	Pastorelli.	Pastorelli.
ter of bulb ...	0·6 in.	0·3 in.	0·5 in.	0·35 in.
ter of jacket...	2·32 in.	2·26 in.	2·02 in.	2·0 in.
1872.	°	°	°	°
24..............	113·5	109·5	114·2	111·2
25..............	112	107·5	112	109
26..............	109·2	104·5	110·7	107·9
27..............	114	109·8	115·2	112
29..............	103	101·2	103	101·5
26..............	102·8	100	104	102
29..............	92·5	88·7	93·2	91
29..............	98·2	95	99	98
30..............	99·8	95·8	100·3	98
8..............	87·2	84·5	87·3	85·3
....	103·22	99·65	103·89	101·59

TABLE V. Comparison of Blackened-bulb Thermometer in Air-pump Receiver with ordinary Blackened-bulb Thermometer *in vacuo*.

Date.	Mean of two b. bulbs *in vacuo*. Corrected.	B.-b. therm. in air-pump Receiver. Corrected.	Diff.
Sept. 12.			
h m			
11 47	121·9	119	2·9
0 2	122·7	121	1·7
0 6	122·8	121·2	1·6
0 12	123·0	122·5	0·5
0 17	120·9	121·5	−0·6
1 13	121·1	121·5	−0·4
Sept. 16.			
10 0	100	102·5	−2·5
10 20	104·5	107	−2·5
10 30	107·8	110	−2·2
10 40	108·8	111	−2·2
10 44	111·2	112	−0·8
10 48	102·5	105	−2·5
Means	113·9	114·5	−0·6

The discussion on this paper will be found at p. 170.

XVII. *On Temperature in Sun and Shade. An account of Experiments made at Harpenden, Herts.* By the Rev. FENWICK W. STOW, M.A., F.M.S.

[Received December 18, 1872. Read January 15, 1873.]

THIS paper is intended to be supplementary to that on Solar Radiation, already submitted to this Society, and is simply an account of some experiments made in September last.

The object proposed was to determine the effect of different conditions of exposure to radiation upon thermometers of different kinds. A number of instruments were most kindly placed at the author's disposal by Mr. Casella. Of these a set comprising a thermometer with a large bulb, an ordinary verified thermometer, of Mr. Casella's "Kew Observatory" pattern, and another of the same kind, but with the bulb blackened, were placed in each of three positions. One set was exposed to the full rays of the sun at 4 feet from the ground; another was placed on what might be called a zenith-stand *, that is, effectually screened from the direct rays of the sun, and from radiation from the ground, but exposed to the sky in the zenith, and to the whole northern heavens; a third was exposed to less than a quarter of the whole sky, and that only near the northern horizon, placed in fact just as on an open stand of the ordinary construction, only that the body of the stand was much deeper and a little wider than usual, and it was only roughly constructed for the special purpose. Care, however, was taken that the usual conditions of an open stand, including free exposure to currents of air, were not departed from. A set of three maximum thermometers, comprising a blackened bulb *in vacuo*

* The apex of the screen in the "zenith-stand" was 2 feet higher than the bulbs of the thermometers, which were from 1 foot to 1 foot 6 inches distant from it horizontally. The front of this stand was about 3 feet wide, the back being formed of boards leaning against it at an angle of about 45°.

and two ordinary maximum thermometers, one of them with a blackened bulb, was also placed in each of these three positions, and also in a fourth position, where they were exposed to the full rays of the sun, but screened from a large part of the sky by a board about 1 foot square overhanging them at 6 inches distance. Lastly, within a louvre-board screen under a large open shed, the thatched roof of which did not come within 10 feet of the ground on the south side and 7 feet on the north side, was placed a set, including all the above-named instruments except the black-bulb maximum thermometer (not *in vacuo*), with the addition of a wet-bulb thermometer. The thermometer with a large bulb, however, was only placed there for a very short time. All these thermometers were carefully re-verified, and the readings have all been corrected for index-error. The "Kew-Observatory" thermometers were newly verified at Kew, and none of them had an index-error exceeding a tenth of a degree. They were all placed with their bulbs perfectly free, so as to be affected by every current of air; and during the experiments there was always a fresh breeze. This would, of course, tend to produce uniformity in the readings; and it is probable that in calm summer weather the differences would have been much greater. Observations were taken only during the middle of the day, and have been classed according to the state of the sky overhead.

One important result of the experiments may be briefly stated thus:—Different thermometers do not agree either in the sun or the shade, unless all sources of radiation and reflection are cut off, as when protected by the louvre-board screen. The thermometer with a bulb 0·56 inch in diameter read 2° or 3° higher in the sun than the "Kew-Observatory" thermometer with a bulb of 0·4 inch diameter; 0°·3 higher on the zenith-stand, and 1° higher on the open stand; but a few observations within the louvre-board screen gave a reading 0°·2 lower than the other. It is not evident why a large bulb, when exposed to radiation, should read higher than a small bulb. Possibly it is because the glass is thicker, as ascertained by the experiments of Mr. B. Loewy, referred to in the previous paper, and therefore more heat is absorbed. But as the large-bulb thermometers were not mounted precisely in the same manner as the others, the experiment should be repeated with unmounted thermometers. The porcelain scale of the large-bulb thermometers came within about 0·5 inch of the bulb; and, though the bulb was perfectly free, the scale may have become hotter than the bulb, and radiated heat to it. The indication of the thermometer with blackened bulb exceeded that of the ordinary thermometer by 6° in the sun, about 1°·2 on the zenith-stand, and from 0°·8 to 1°·7 on the ordinary stand. A thermometer with spirit coloured red, which was tried on the stand, indicated 0°·9 higher than the "Kew Observatory." Of the maximum thermometers, the blackened bulb *in vacuo* (which may be called the solar thermometer) exceeded the ordinary maximum by 10° on the zenith-stand, and 4° on the ordinary stand; while within the screen it fell 0°·2 below it, probably owing to its being less sensitive. Comparing next the temperatures marked by the similar "Kew-Observatory" thermometers in the different positions, it was found that with full sun and zenith clear, it was only

3°·4 hotter in the sun than in the louvre-board screen; but with the zenith overcast it was 5° hotter, and with the sky hazy 3°·7. On the zenith-stand it was 0°·5 warmer than in the screen when the sky was clear, but 1°·5 when overcast in the zenith, 0°·8 when hazy, 1°·1 when nearly overcast. On the open stand it was 1°·2 warmer than in the screen when the sky was clear, 1°·4 when it was overcast in the zenith, 0°·9 when hazy, and 0°·6 when nearly overcast. The ordinary maximum thermometers read 4° higher in the sun than within the screen; and this excess was increased to 5° by screening the zenith; diminished to 1°·5 on the zenith-stand, but on the ordinary stand it was no less than 3°·6. The thermometer used on this stand was one by Negretti and Zambra, made more than fourteen years ago, and which previously scarcely ever differed more than 0°·1 from the Phillips's maximum thermometer placed in the screen, when both were in a louvre-board screen together. It had a larger bulb than the other unblackened maximum thermometers, and was mounted while they were not.

These figures indicate some facts worthy of remark. First, with regard to the zenith-stand, it appears that when the sky is nearly clear the small portion of the reflected rays, which a bright mercurial bulb absorbs, scarcely more than counterbalances at noon in September the heat radiated from the bulb into space. But when the zenith becomes overcast, or nearly so, on a fine day the thermometer on the zenith-stand marks a degree or two above the temperature of the air, showing that the solar heat received from the clouds exceeds the diminished effect of the bulb's own radiation by that amount. In the next place, by cutting off the greater portion both of this reflected heat and of the bulb's own radiation; but, at the same time, admitting radiated or reflected heat from the ground, the temperature is not lowered but raised, the only exception being when the reflection from the clouds is at its maximum, owing to the zenith being overcast with bright cumuli; in which case the excess of cloud-reflection over radiation into space nearly equals in amount the radiation from the ground. In short, the temperature of a thermometer placed on an ordinary open stand is raised above the temperature of the air, not so much by the reflection from the small portion of the sky to which it is exposed, as by radiation or reflection from the ground. But as there cannot be much reflection from green grass, the effect must be principally due to radiated heat.

In order, however, to establish this conclusively by a more direct experiment, two similar verified "Kew-Observatory" thermometers were placed on the open stand, exactly as the dry- and wet-bulb thermometers are usually placed; but 1 inch below the bulb of one of them a board of a dull colour was fixed, to intercept the radiation or reflection, if any, from the ground, without any appreciable amount of the heat from the clouds being reflected from the board to the bulb. Two other "Kew-Observatory" thermometers were also placed inside the stand, both screened from the whole sky, but one exposed to heat-rays proceeding from the ground, and the other sheltered from them. It was now late in September, and rain had fallen, making the ground much colder than it had previously been. Still it was found that of the two first, the thermometer screened

from the ground read 0°·6 lower than the one not so screened, and in the case of the two latter the difference was 0°·9, the thermometer screened from both sky and ground reading nearly the same as that in the louvre-board screen. The effect of screening the portion of sky to which the two first thermometers were exposed was less considerable. When the sky was less than half overcast the temperature was thereby raised 0°·15, and when more than half overcast it was depressed 0°·34.

It follows therefore that the excess of temperature indicated by a thermometer on an ordinary open stand over that shown by one in a Louvre-board screen is mainly the result of radiation from the ground, the rays from which, being almost wholly obscure, are readily absorbed by the glass of the bulb, whereas the solar rays reflected by clouds, being of much greater refrangibility, are most of them transmitted through the glass, and reflected from the bright surface of the mercury. Indeed, remembering that the thermometers in full sun were affected, not only by direct solar radiation, but by reflection from clouds and radiation from the ground, it is possible that in summer an ordinary thermometer, placed at 4 feet above the surface, acquires more heat from the ground than even from the direct rays of the sun at noon. This explains how it is that the excess of maximum temperature on an open stand above that registered within a screen is greatest in summer, when the ground is very much hotter than the air, and nearly vanishes in winter, when even in the middle of the day the ground is no warmer than the air. But, while a bright mercurial bulb is a very bad absorbent of rays of great refrangibility, the solar thermometer, on the contrary, is very sensitive to their influence*. Hence the sun's rays reflected from clouds were found to raise the temperature of the solar thermometer on the zenith-stand some 10° or 11°. And again, if exposed to the sun, but screened from the bright clouds overhead, it was found to read more than 4° *lower* than if not so screened, although an ordinary thermometer by its side, whether blackened or not, rose 1°, the loss of reflected heat being in this case masked by the gain resulting from the interception of the bulb's own radiation. (See Table V., A & E.) Suppose the whole effect of the latter to be 3° on both instruments, then that of reflected heat on the ordinary thermometer was 2°, and on the solar thermometer was $4°+3°=7°$, or about $\frac{1}{8}$ of the total solar radiation. This reflected heat appears to account for the increase of solar radiation which may be observed, either with a solar thermometer or an actinometer, whenever a bright cloud is approaching the sun, and, partially, for the smaller amount of solar radiation on cloudless days than on days when there are cumuli. It must be remembered, however, that on cloudless days it is often hazy.

The conclusions to be drawn from these experiments have gone quite beyond the immediate objects at first in view. It was evident that a

* The solar rays pass through the external glass and affect the bulb directly; but, being there converted into obscure rays to which glass is opaque, they must first be radiated to the glass and then pass by conduction to its outer surface before they can finally escape. These instruments, therefore, are powerfully and rapidly affected by the sun's heat, but by other influences more slowly, and not to a greater extent than an ordinary thermometer.

thermometer with a blackened bulb not *in vacuo*, if raised above the ground, gave a much better test of the strength of the wind than of the heat of the sun. It was evident also that for the purpose of measuring solar radiation, it did not much signify whether the shade-temperature used was that on an open stand or in a louvre-board screen, but that it ought to be one or the other; and it will be necessary to wait for the Strathfield Turgiss experiments for figures by which to reduce one to the other. The results of these experiments have, however, a more general interest. Without attempting to anticipate the verdict of competent authorities based on the elaborate and exhaustive experiments at Strathfield Turgiss, the author would just point out two facts which his experiments have decided. First, that thermometers with bulbs possessing unequal radiating properties do not agree if plåced on an open stand, but do agree most exactly within a louvre-board screen; that is to say, that thermometers containing coloured spirit will not agree with those containing mercury; and, what is still more important, a bulb covered with muslin will not agree with an uncovered bulb. On an open stand the wet bulb is affected by radiation differently from the dry bulb, and must, if the muslin be allowed to become dry on a fine summer's day, read higher than the dry bulb. Any one can verify this result for himself, which was observed by the author long before he suspected the reason. Secondly, that it is impossible for thermometers on an open stand to show the true temperature of the air, since their temperature is raised in the daytime, by radiation from the ground, to an extent depending upon the difference of temperature between the ground and the air, and is also affected somewhat by the state of the sky. At night, on the contrary, their temperature is depressed below the air-temperature; which is proved by the occasional deposition of dew and hoar-frost upon them. In sunny weather, when there is snow on the ground, the maximum temperature is much higher on an open stand than within a screen, owing no doubt to reflection from the snow.

Open stands have done good service; but it is difficult to see why they should continue to be used, unless for the purpose of comparison with old observations. The opinion of an individual observer is a matter of very little moment; but there would seem to be sufficient reasons for a preference for a louvre-board screen.

The stands were visited, and the thermometers read, in the order in which they appear in the Tables. As most of the observations were taken at the time of the day when the temperature is upon the whole nearly stationary, it was not considered that any thing would be gained by incurring the inconvenience of altering the order. They were read by one person, and the figures put down by another, the time occupied in reading being about a minute. When all had been read, those first read were again examined, and if much change had occurred the observation was rejected; if but little, another reading was taken in the reverse order, and the mean of the two counted as one observation. The self-registering thermometers were read afterwards, when necessary. The instruments were generally exposed before 10 A.M. and removed at 4 P.M.

Thermometers of Different Kinds and under Different Conditions of Exposure.

TABLE I. With full Sun and Zenith clear.

Date, 1872.	No. of Obs.	A. Thermometers exposed to full sun.			B. Thermometers screened from sun and ground, but exposed to zenith and northern sky.			C. Thermometers screened from sun and from ⅞ sky.				D. Complete shade of louvre-boards under shed.			Cloud.		Wind.
		Large bulb.	Ord.	Black bulb.	Large bulb.	Ord.	Black bulb.	Large bulb.	Ord.	Black bulb.	Red spirit.	Ord.	Black bulb.	Wet.	Amount.	Character.	Hourly Velocity.
		°	°	°	°	°	°	°	°	°	°	°	°	°			miles
Sept. 2, noon	4	78.2	75.7	82.7	71.6	71.4	72.6	73.6	73.3	74.2	74.3	71.1	71.1	62.5	3	cum.	15
" 5, 11 A.M.	2	75.6	73.5	81.3	69.7	69.6	70.9	70.9	69.9	72.2	71.1	68.1	68.3	61.4	3	cum.	14
" 6, noon	1	73.6	72.0	78.0	68.4	67.9	69.1	69.4	68.4	70.1	69.4	67.6	67.8	60.9	5	cum.	19
" 6, 12.15 and 12.20	2	73.6	72.2	78.5	69.4	68.9	70.1	70.2	69.1	70.7	70.3	68.3	68.3	61.2	4	cum.	21
" 6, 12.25 and 12.30	2	75.4	73.6	80.2	69.8	69.5	70.7	70.8	69.7	71.5	70.2	68.6	68.6	61.3	3	cum.	21
" 7, 3.45 P.M.	1	68.6	67.5	71.0	66.4	66.1	66.6	67.9	66.9	67.9	67.6	66.5	66.5	59.7	1	cir.	23
" 12, 1.10 P.M.	1	[75.4]	73.5	79.0	71.3	71.1	72.6	72.7	71.9	73.6	[72.8]	70.6	70.7	63.5	4	cum.	23
" 13, 11.52 A.M.	1	[75.7]	73.8	79.0	72.3	72.1	73.1	75.4	73.1?	76.1	[74.0]	71.3	71.9	66.5	4	cir. c.	10
" 13, 3.25 P.M.	1	[77.5]	75.0	78.5	74.3	74.1	75.1	75.9	74.9	76.3	[75.8]	74.0	74.0	65.9	4	cum.	11
Mean of 9 observations	...	74.84	72.98	78.69	70.35	70.07	71.20	71.86	70.80	72.51	71.72	69.56	69.68	62.54	3.4	...	17.4

TABLE II. Full Sun and Zenith Overcast.

Sept. 2, 2.30 P.M.	1	80.3	76.0	81.7	73.3	72.6	72.6	74.4	73.4	74.6	...	71.9	72.0	63.4	6	cum.	15
" 5, 10.45 A.M.	1	73.0	71.3	78.5	68.3	67.9	69.4	68.4	67.3	68.9	...	65.9	66.1	60.4	4	cum.	14
" 5, noon	1	76.8	75.0	82.0	72.3	71.6	72.9	72.4	71.1	72.6	...	69.3	69.3	61.1	5	cum.	18
" 6, 12.10 P.M.	1	73.5	72.0	78.0	69.6	69.1	70.6	69.9	69.1	70.9	...	68.1	68.1	60.9	5	cum.	21
Mean of 4 observations	...	75.90	73.78	80.05	70.88	70.30	71.38	71.28	70.22	71.75	...	68.80	68.88	61.20	5	...	17

Table III. Sun Shining, but Sky Hazy.

Date, 1872.	No. of Obs.	A. Thermometers exposed to full sun.			B. Thermometers screened from sun and ground, but exposed to zenith and northern sky.			C. Thermometers screened from sun and ¾ sky.			D. Complete shade of louvre-boards under shed.			Cloud.		Wind.
		Large bulb.	Ord.	Black bulb.	Large bulb.	Ord.	Black bulb.	Large bulb.	Ord.	Black bulb.	Ord.	Black bulb.	Wet.	Amount.	Character.	Hourly Velocity.
		°	°	°	°	°	°	°	°	°	°	°	°			miles
Sept. 3, 1.25 P.M.	2	83.3	81.1	87.0	79.0	78.6	79.3	79.1	78.4	79.3	77.1	77.1	67.3	3	cir.	23
„ 3, 2 P.M.	1	82.7	80.0	85.0	77.8	77.3	78.1	78.2	77.4	78.1	76.8	76.9	66.1	5	cir.	23
„ 3, 2.15 P.M.	1	84.0	81.5	87.5	79.3	78.6	79.7	79.4	78.7	79.7	77.6	77.6	67.4	3	cir.	23
„ 4, 1 P.M.	1	77.5	75.5	79.5	73.3	72.9	73.9	73.9	73.2	73.9	72.6	72.6	66.9	6	cir. s.	11
„ 4, 1.30 P.M.	1	78.4	76.8	83.8	73.8	73.1	74.6	73.9	73.4	74.1	72.4	72.4	66.9	6	cir. s.	11
Mean of 5 observations ...	...	81.18	78.98	84.56	76.64	76.10	77.12	76.90	76.22	77.02	75.30	75.32	66.92	4.6	...	18.2

Table IV. Sky nearly Overcast.

Date, 1872.	No. of Obs.	A. Large bulb.	A. Ord.	A. Black bulb.	B. Large bulb.	B. Ord.	B. Black bulb.	C. Large bulb.	C. Ord.	C. Black bulb.	D. Ord.	D. Black bulb.	D. Wet.	Cloud Amount.	Cloud Character.	Wind Hourly Velocity.
Sept. 4, 10.30 A.M.	2	73.0	71.7	74.4	73.2	72.1	74.0	71.7	71.2	71.9	70.6	70.6	66.1	10	cir. c. & cir. s.	14
„ 6, 12.35 P.M.	1	69.0	68.0	69.8	69.3	68.6	70.1	68.9	67.4	68.4	67.3	67.3	60.5	8	cum.	21
„ 8, 1 P.M.	1	62.3	61.5	63.0	63.3	62.6	64.1	63.4	61.9	62.6	60.9	60.9	53.9	10	cir. c.	17
„ 12, 3.30 P.M.	1	[69.0]	68.0	69.5	69.3	68.1	69.6	69.1	68.7	69.3	68.1	68.1	63.5	9	cum.	19
Mean of 4 observations ...	...	68.42	67.30	69.18	68.78	67.85	69.45	68.28	67.30	68.05	66.72	66.72	61.00	9.2	...	17.7

TABLE V. Extremes registered by Maximum Thermometers.

Date.	A. Thermometers exposed to full sun.			E. Thermometers exposed to full sun, but with zenith sheltered.			B. Thermometers screened from sun and ground, but exposed to zenith and northern sky.			C. Thermometers screened from sun and from ¾ sky.			D. Complete shade of louvre-boards under shed.	
	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Ord.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Sept. 5, 11 A.M.	119·0	86·8	74·2	119·0	85·6	74·7	75·0	72·0	70·0	75·7	72·5	71·7	69·0	69·3
„ 5, 1.30 P.M.	125·5	86·8	77·0	123·8	86·6	76·7	80·5	75·3	72·3	79·0	74·8	74·2	70·8	70·7
„ 6, 12.35 P.M.	124·0	83·0	72·8	122·5	84·1	74·7	74·2	72·5	70·0	77·6	73·0	72·7	70·3	69·1
„ 8, 4 P.M.	121·0	81·3	70·2	114·5	85·1	72·7	79·5	74·0	66·3	72·8	69·3	68·5	64·8	64·9
„ 10, 4 P.M.	125·5	77·8	70·0	115·8	79·1	69·2	84·5	72·7	68·8	73·0	70·0	69·2	65·6	66·0
„ 12, 4 P.M.	119·0	82·8	75·2	116·0	83·1	75·7	85·5	76·0	71·8	77·8	74·8	74·2	70·8	70·9
„ 13, noon	122·8	83·3	74·2	118·0	85·1	75·2	80·0	77·7	72·8	79·5	76·6	75·7	70·8	71·8
„ 13, 12.20 P.M.	124·2	83·8	75·2	120·0	86·1	76·2	83·0	78·0	73·3	80·5	77·3	76·7	72·3	73·1
„ 13, 1.20 P.M.	122·0	84·8	76·4	117·0	86·3	77·7	86·0	78·3	75·0	80·0	77·8	77·0	73·0	73·7
„ 13, 3.25 P.M.	129·0	87·6	78·7	123·2	87·6	79·2	92·0	80·3	76·8	83·5	79·8	79·1	75·0	75·0
Mean of 10 observations...	123·20	83·80	74·39	118·98	84·87	75·20	82·52	75·68	71·71	77·92	74·59	73·90	70·24	70·45

TABLE VI. Similar Thermometers under Different Conditions of Exposure.

Exposed to	1. Ground and ½ sky.	2. ½ sky and not ground.	3. Ground and not sky.	4. Neither.	5. In louvre-board screen.
	°	°	°	°	°
Cloud 5 or more ...	60·6	60·4	60·2	59·8	59·5
	63·0	62·3	62·5	61·8	61·6
	53·0	52·4	53·2	52·4	52·3
	51·3	51·0	51·0	50·7	50·6
	53·7	52·9	53·5	52·3	52·3
	56·0	55·1	55·9	54·4	54·1
	56·27	55·68	56·05	55·23	55·07

Exposed to	1. Ground and ½ sky.	2. ½ sky and not ground.	3. Ground and not sky.	4. Neither.	5. In louvre-board screen.
	°	°	°	°	°
Cloud less than 5 ...	51·6	51·1	52·0	50·9	50·9
	54·2	53·6	54·5	53·7	53·1
	45·8	45·1	45·9	45·0	44·9
	51·4	51·0	51·5	50·9	50·6
	50·8	50·1	51·0	50·1	50·3
	52·3	51·8	53·0	52·1	52·1
	51·5	50·9	52·0	50·7	50·1
	51·09	50·51	51·41	50·49	50·29

The discussion on this paper will be found at p. 172.

XVIII. *Remarks on the "Pocky" Cloud observed July 27th*, 1872.

By J. S. HARDING, F.M.S.

[Received December 18, 1872. Read January 15, 1873.]

IT may be interesting to know that I observed a very fine specimen of the "Pocky" cloud at Havre, on Saturday, the 27th of July last. The day had been very fine and hot; but between 4^h and 5^h P.M. the sky became quickly overcast; and from 5^h to 6^h P.M. the place was visited by a heavy thunderstorm, the wind blowing very strongly in gusts.

So far as the rain was concerned, I do not remember having seen any thing to equal it before. I was staying in the Grande Rue, one of the widest streets of the town, and being situated at the foot of high hills, in a few minutes it became like a river, the water reaching almost to the horses' knees in some parts.

By about 6^h 30^m P.M. the storm had entirely passed, and on going out I at once observed that nearly all the sky, excepting near the horizon, was covered with the peculiar clouds in question.

The cloud very much resembled the illustration given in the 'Journal of the Meteorological Society' for 21st of February last, excepting that the festoons appeared to be much larger and more decided, and not so closely

packed; while drifting to the westward, portions became quite detached, but still retained the sugar-loaf shape. It seems also worthy of notice that the storm *preceded* the cloud in this case.

I called at the Pier-master's Office at about 8^h P.M. He had not noticed the phenomenon, nor could I get any particulars from him as to whether it was a rare occurrence. There was no irregularity in the tides that day.

The following data before and after the storm are taken from the Paris 'Bulletin International' for Havre.

Date.	Hour.	Barometer.	Thermometer.	Wind.		Weather.	Sea.
				Direction.	Force.		
1872.		in.	°				
July 27 ...	7 A.M.	30·040	68·0	S.S.E.	Light.	O.	Calm.
„ 27 ...	6 P.M.	......	......	N.E.	Strong.		
„ 28 ...	7 A.M.	30·138	65·3	S.	Light.	M.	Calm.
„ 28 ...	6 P.M.	......	......	N.E.	Mod.		
„ 29 ...	7 A.M.	29·922	67·6	S.	Light.	M.	Calm.

The rain was not stated for Havre; but 0·985 inch was recorded at Paris on the morning after the storm.

XIX. *Account of the Hurricane which passed over the Nichol Bay district of Western Australia on March 20th,* 1872. By R. J. SHOLL, Government Resident. (Abridged from the 'Inquirer' newspaper of May 15th, 1872.)

[Received December 18, 1872. Read January 15, 1873.]

It is with sorrow that I have to report a serious disaster at Roebourne on the evening of the 20th of March, when a hurricane swept the district, levelled (with the exception of two outhouses) every building, caused much damage to station property, and destroyed many head of large and small stock. The usual warning was not given. The daily average of the barometer from the 10th to the 31st of January was 29·82 in.; for the month of February 29·82 in.; and for the 19 days of March preceding the cyclone, 29·83 in. During this period we had showers, with occasional heavy, but steady rain, and congratulated ourselves upon the propitious season. Considering that it was the height of the hot season, the thermometer did not range high; but the heat was oppressive, and the atmosphere close and damp. On the 19th of March the barometer stood at 29·78 in.; no wind during the day, cloudy, and threatening rain. At 8 P.M. there was a moderate E. wind and rain, which fell steadily during the night. On the 20th, at 8.15 A.M., the barometer indicated 29·63; thermometer 79° (it was not lower than 78° throughout the day); wind, light from the S.E. At 11 A.M. barometer 29·58 in.; raining heavily, occasional strong gusts from the S.E.; river Harding flooded. At 1.10 P.M. barometer 29·50 in.; wind from the same quarter, but increasing in strength; river-flood extending, and rain descending in cataracts. At 2.10 P.M. barometer 29·44 in., wind, flood, and (if possible) rain increasing. At 4.10 P.M. barometer 29·29 in.; strong

gale from S.E., heavy rain. At the Residency plaster falling in large masses from the rocking of the building; portions of interior wall of kitchen damaged by wet. At 5.10 P.M. barometer 29·18 in., very strong S.E. gale with rain; plaster falling from lee side of the Residency. This is the last entry I made, as the rain and wind would not permit me to keep a light burning in the office; but I recollect that at 6.10 P.M. the barometer read 28·96 in. Shortly after this mortar and small stones fell so fast in the office that I left it, getting out of a window facing north, fearing to open the doors, which all faced the gale.

I was scarcely outside when I was driven before the wind, knocked over and rolled along, the roof of the office falling around me, and small pieces striking me. Here I must have been struck heavily, but do not recollect it; for, when I recovered from insensibility, I was lying on my face with my fingers dug into the ground: I could not move easily, or without pain. I attempted to get towards the bush-hut; but in the haze, and with the rain beating in my face, went in the wrong direction, and was finally blown back. As I was rolling along, I caught hold of a rock and with difficulty got to the leeward of it. I was here several hours, several attempts to get to the bush-hut being unsuccessful, with the gale still at its height, and in my disabled condition. During this time the wind had not abated, but had gradually shifted from S.E. to E., thence N.E., and later to N., when it diminished in force. It was moonlight, but the dense clouds and driving rain rendered it impossible to distinguish objects within a few feet. When the wind had veered N., and there was a partial lull, the sky was sufficiently clear to enable me to see by the misshapen shadows in the haze that every building was down.

There was a lull for about an hour after 10 P.M., after which the wind shifted to the westward, and blew until daylight with great violence. It gradually veered S., and moderated; and at 8 A.M. on the 21st it was calm. From what I can learn, it appeared that all the buildings in Roebourne were destroyed within half an hour of each other. No matter how they were built, or of what material, they went in the direction of the wind. As a general rule the roofs were the first to yield. My watch, broken by the fall of the office-walls, had stopped at 6.55 P.M., and at or about that time the ruin of Roebourne was effected.

The flood was higher than has yet been known, not only at Roebourne, but throughout the district; and much damage was done by the overflow of the rivers.

At Cossack the gale blew with great violence; and although it was neap tide, the water in the inlet swept over the bank, and was 18 inches high in Mr. Howlett's store. Had it been spring tide, all buildings not on the sandy ridge would have been swept away.

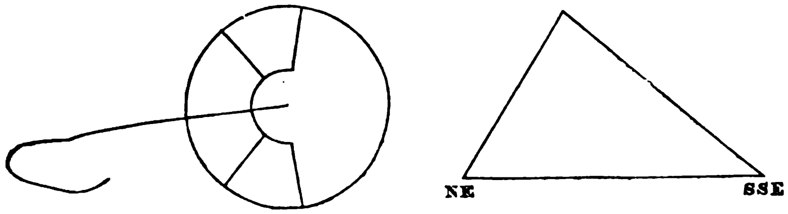
I may state that, as on former occasions, the cyclone did not extend in force beyond the Maitland to the westward, nor did it reach the De Grey to the eastward. At Condon there was a strong gale a few days earlier (March 16), which, had it lasted, would have sunk, or blown ashore, many of the pearl boats; but happily no mischief was done.

XX. *Extract from Log of Barque 'Lady of the Lake.'* By Capt. FREDERICK WILLIAM BANNER. (Communicated by R. H. SCOTT, F.R.S.)

[Received December 18, 1872. Read January 15, 1873.]

22nd March, 1870. Lat. N. 5° 47′, long. W. 27° 52′.

AT from 6.30 to 7 P.M. a curious-shaped cloud appeared in the S.S.E. quarter, first appearing distinct at about 25° from the horizon, from where it moved steadily forward, or rather upward, to about 80°, when it settled down bodily to the N.E. Its form was circular, with a semicircle to the northern face near its centre, and with four rays or arms extending from centre to edge of circle. From the centre to about 6° beyond the circle was a fifth ray broader and more distinct than the others, with a curved end :—diameter of circle 11°, and of semicircle 2½°. The weather was fine, and the atmosphere remarkably clear, with the usual Trade sky. It was of a light grey colour, and, though distinctly defined in shape, the patches of cirro-cumulus at the back could be clearly seen through. It was very much lower than the other clouds ; the shape was plainest seen when about 55° to 60° high. The wind at the time was N.N.E., so that it came up obliquely against the wind, and finally settled down right in the wind's eye ; finally lost sight of it through darkness, about 30° from the horizon at about 7.20 P.M. Its tail was very similar to that of a comet. The men forward saw it nearly 10 minutes before I did, and came aft to tell me of it. This may give a rough idea of its shape and track ; its general appearance was similar to that of a halo round the sun or moon.



XXI. *Description of an Electrical Self-registering Anemometer and Rain-gauge.* By the Rev. F. W. STOW, M.A., F.M.S.

[Received January 9, 1873. Read February 19, 1873.]

THE general principle on which the registering apparatus is constructed is that of the Morse telegraph instrument. Mr. Louis J. Crossley suggested to me the application of this principle, which he had himself successfully worked. He caused a clock to draw a narrow strip or tape of paper through a vessel containing a solution of ferrocyanide of potassium. As the wet paper passed over an iron roller, in connexion with one pole

of a battery, the registration was effected by an iron style in connexion with the other pole being drawn down upon the paper by an electro-magnet, a dot of Prussian blue resulting. I tried this, and got it to work satisfactorily; but the limited supervision I was able to give to an instrument nearly a mile from my house caused me to look out for a simpler method, in which it should not be necessary to use any liquids.

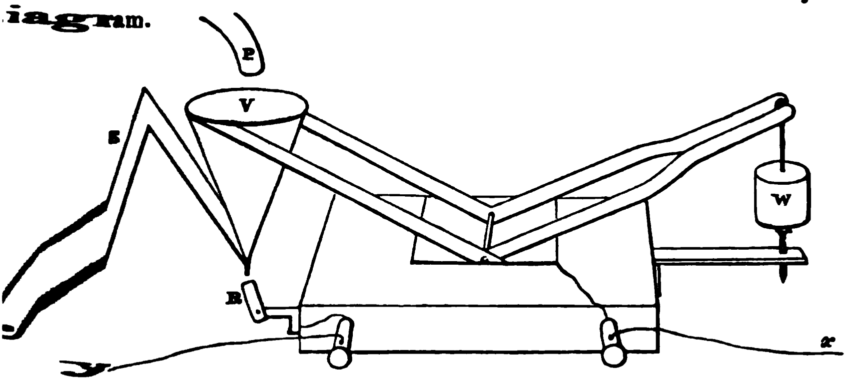
My plan is the following, similar in principle, I believe, to the mode in which the Morse telegraph instruments are worked in America. The tape is drawn by a clock at the uniform rate of 6 inches n each hour. As it passes over a grooved brass roller, holes are punched in it by a sharp steel point, drawn down by an electro-magnet, whenever the electric circuit is completed, and drawn back by a spiral spring when the contact is broken. There are two grooves in the roller, and two electro-magnets, one of which is worked by the anemometer, and the other by the rain-gauge; thus, when both magnets are in operation, two parallel rows of holes are punched in the tape.

The anemometer is arranged to make and break contact once for every mile of wind which passes it; the rain-gauge once for every hundredth of an inch which has fallen. The results are reduced to figures simply by measuring the tape on a scale fixed to a table, and counting the number of dots in each space of 6 inches. It is desirable that the steel point should be weighted, and carried on a somewhat elastic strip of metal, in order that the hole may be punched by the first blow, and the point extricate itself with ease, even if the contact (which ought to be as short as possible) should happen, as in a calm, to be prolonged.

The anemometer employed is an old one by Adie, which was used in the anemometrical experiments which I made at Hawsker. It has 4-inch cups, and these were originally fixed on arms 5·6 inches in length. Instead of doubling the length of arm, I increased it only to 9 inches, and found that the instrument so altered showed upon its scale at all velocities at which it was tested, viz. up to 40 miles an hour, from 50 to 51 per cent. of the number of miles marked by a large "Kew pattern" instrument, the difference between 9 and 11 inches in the length of arm being sufficient to allow for the difference between large and small instruments. I then placed two pins upon the face of the wheel, which now revolved once for every two miles of wind that passed; these pins were made to thrust a platinum-tipped rod in connexion with one pole of the battery against a platinum-covered spring in connexion with the other. A contact was thus made once for every mile of wind which would have been marked by a Kew standard anemometer.

It is a much more difficult thing to obtain a good contact-maker for a rain-gauge. I tried at first a float rising in a cylinder, from which a thread passed over a wheel, and was kept tight by a small counterpoise. There were a number of pins on the wheel, and each of these as it passed moved a lever, the other end of which made a contact with a platinum-faced spring. This worked very fairly; but, as in all such contrivances, it was found that friction was a hindrance to complete accuracy.

The contact-maker which I then contrived will be understood by the diagram.



P is the pipe conveying the rain from a gauge 12 inches in diameter. V is a small vessel into which it falls (there is a sort of trap in the pipe, to prevent the wind blowing down it). When 285 grains ($=\frac{1}{100}$ inch) have fallen into V, the weight W is raised from its support, and the balance continuing to move (as from its shape it necessarily must do), a platinum point on the bottom of V strikes against a platinum surface on the spring R, and V being connected by the wire x with one pole of the battery, and R by the wire y with the other, the current immediately passes, bringing an electro-magnet into play, and recording the fall on the registering tape. By this time the water in V has run up to the head of the siphon S, and the siphon coming into play discharges the water, upon which V again rises, and the contact is broken, the whole process occupying about 3 seconds. The advantage of this gauge is that it is an independent standard, every hundredth of an inch being exactly weighed off. The weight W rests upon a screw, by which the position of W, and therefore the weight of water required to raise it, may be regulated to some degree of nicety. If the rain is very heavy, the quantity which falls from P during the 3 seconds between the fall and the rise of the balance, and which is discharged with the rest, becomes appreciable, and a correction for this loss may easily be calculated and applied. It is evident that the same principle might be applied to a mechanical registration, by making the fall of the balance work an escapement, and so drive a spiral pencil upon paper wrapped round a cylinder driven by a clock.

I see no reason why electrical anemometers and rain-gauges on this principle should not be very generally adopted by those to whom the cost of most other recording instruments is a serious obstacle. The following is a rough estimate of the cost for which such an apparatus as I have described may be made, if high finish is not required:—

	£	s.
Registering apparatus with c lock and two electro-magnets	5	0
Batteries	2	0
Anemometer cusp and wheel-work with contact-maker.	3	10
Rain-gauge with contact-maker	2	10
	13	0

The anemometer or rain-gauge singly would cost about £8 or £9; and those who have already a set of cups might get the former made for about £6.

Most of the electrical apparatus was made for me by Mr. Lund, of Brook-street, Holborn. The battery I use is a Daniell's, on Sir W. Thomson's specific-gravity principle, the plates of zinc and copper being 8 inches in diameter, and the separation being maintained by a piece of stout paper. Such a battery is cheap, powerful, and constant. The vessels I have used for it are common earthenware milk-pans. They are filled with a saturated solution of sulphate of zinc, and crystals of copper sulphate are dropped to the bottom. Six cells give sufficient power. A small Leclanché battery works the rain-gauge; but a constant battery would be better even for this *; and for the anemometer it is absolutely necessary, since the contacts are more frequent.

The above-described instruments have been in continuous operation for more than three months †. When the adjustments are all complete, the only attention they require is winding up the clock, and replenishing the battery with copper sulphate. The supply of tape lasts about ten weeks. The great advantage of having both anemometer and rain-gauge at a distance from buildings, and yet the clock and registering apparatus indoors, is an obvious recommendation of the use of electricity for these purposes.

Postscript.

Mr. Stow then asked leave to exhibit a small electrical registering machine belonging to Mr. L. J. Crossley, and also a drawing of an electro-magnetic apparatus by which the necessity of batteries and contact-makers was superseded. The former consisted of a clock turning a cylinder in twenty-four hours, across which a pencil moved in the grooves of a double endless screw, the latter being permitted to revolve by an escapement worked by an electro-magnet, as in Breguet's "Compteurs Electriques." In the latter, the force of the revolving cups was applied by means of a lever to withdraw an electro-magnet from a permanent magnet, thus generating a current of electricity in the wires of the electro-magnet ‡. Mr. Stow also exhibited his own rain-gauge contact-maker, and a cell of the battery described above.

The discussion on this paper will be found at p. 174.

XXII. *On the Madras Cyclone of May 2nd*, 1872. By Capt. H. Toynbee, F.R.A.S., Marine Superintendent of the Meteorological Office.

[Received January 15, 1873. Read February 19, 1873.]

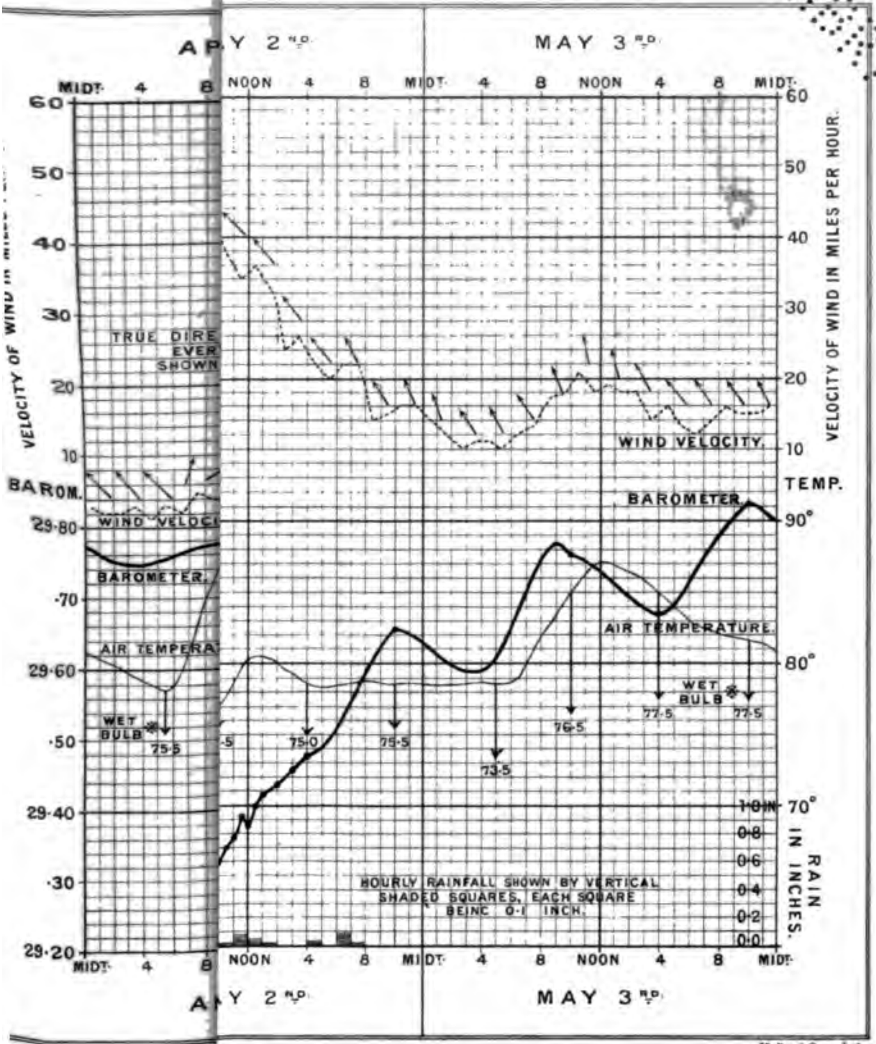
This paper is accompanied by extracts from the logs of H.M.S. 'Orontes,' the 'Inverness,' and the S.S. 'Durley,' sent into the Meteorological Office,

* The Leclanché battery has since been discarded in favour of another Daniell's battery like that described.

† Now, April 30th, nearly eight months.

‡ The necessary quickness of withdrawal is obtained by the use of a cam which, for simplicity's sake, was not shown in the drawing.

ROJECTION oN AND HOURLY VELOCITY OF WIND, AND RAINFALL
E OF MAY, 1872.
MER.



Malby & Sons, Lith.

nd figures giving the actual readings.

TABLE III. Sun Shining, but Sky Hazy.

Date, 1872.	No. of Obs.	A. Thermometers exposed to full sun.			B. Thermometers screened from sun and ground, but exposed to zenith and northern sky.			C. Thermometers screened from sun and ¾ sky.			D. Complete shade of louvre-boards under shed.			Cloud.		Wind.
		Large bulb.	Ord.	Black bulb.	Large bulb.	Ord.	Black bulb.	Large bulb.	Ord.	Black bulb.	Ord.	Black bulb.	Wet.	Amount.	Character.	Hourly Velocity.
		°	°	°	°	°	°	°	°	°	°	°	°			miles
Sept. 3, 1.25 P.M.	2	83.3	81.1	87.0	79.0	78.6	79.3	79.1	78.4	79.3	77.1	77.1	67.3	3	cir.	23
" 3, 2 P.M.	1	82.7	80.0	85.0	77.8	77.3	78.1	78.2	77.4	78.1	76.8	76.9	66.1	5	cir.	23
" 3, 2.15 P.M.	1	84.0	81.5	87.5	79.3	78.6	79.7	79.4	78.7	79.7	77.6	77.6	67.4	3	cir.	23
" 4, 1 P.M.	1	77.5	75.5	79.5	73.3	72.9	73.9	73.9	73.2	73.9	72.6	72.6	66.9	6	cir. s.	11
" 4, 1.30 P.M.	1	78.4	76.8	83.8	73.8	73.1	74.6	73.9	73.4	74.1	72.4	72.4	66.9	6	cir. s.	11
Mean of 5 observations	...	81.18	78.98	84.56	76.64	76.10	77.12	76.90	76.22	77.02	75.30	75.32	66.92	4.6	...	18.2

TABLE IV. Sky nearly Overcast.

Date, 1872.	No. of Obs.	A. Large bulb.	A. Ord.	A. Black bulb.	B. Large bulb.	B. Ord.	B. Black bulb.	C. Large bulb.	C. Ord.	C. Black bulb.	D. Ord.	D. Black bulb.	D. Wet.	Cloud Amount.	Cloud Character.	Wind Hourly Velocity.
Sept. 4, 10.30 A.M.	2	73.0	71.7	74.4	73.2	72.1	74.0	71.7	71.2	71.9	70.6	70.6	66.1	10	cir. c. & cir. s.	14
" 6, 12.35 P.M.	1	69.0	68.0	69.8	69.3	68.6	70.1	68.9	67.4	68.4	67.3	67.3	60.5	8	cum.	21
" 8, 1 P.M.	1	62.3	61.5	63.0	63.3	62.6	64.1	63.4	61.9	62.6	60.9	60.9	53.9	10	cir. c.	17
" 12, 3.30 P.M.	1	[69.0]	68.0	69.5	69.3	68.1	69.6	69.1	68.7	69.3	68.1	68.1	63.5	9	cum.	19
Mean of 4 observations	...	68.42	67.30	69.18	68.78	67.85	69.45	68.28	67.30	68.05	66.72	66.72	61.00	9.2	...	17.7

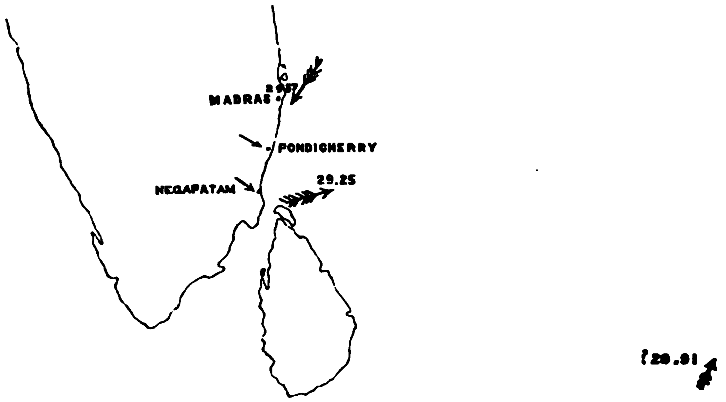
TABLE V. Extremes registered by Maximum Thermometers.

Date.	A. Thermometers exposed to full sun.			E. Thermometers exposed to full sun, but with zenith sheltered.			B. Thermometers screened from sun and ground, but exposed to zenith and northern sky.			C. Thermometers screened from sun and from ¾ sky.			D. Complete shade of louvre-boards under shed.	
	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Black bulb	Ord.	Black bulb *in vac.*	Ord.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Sept. 5, 11 A.M.	119·0	86·8	74·2	119·0	85·6	74·7	75·0	72·0	70·0	75·7	72·5	71·7	69·0	69·3
„ 5, 1.30 P.M.	125·5	86·8	77·0	123·8	86·6	76·7	80·5	75·3	72·3	79·0	74·8	74·2	70·8	70·7
„ 6, 12.35 P.M.	124·0	83·0	72·8	122·5	84·1	74·7	74·2	72·5	70·0	77·6	73·0	72·7	70·3	69·1
„ 8, 4 P.M.	121·0	81·3	70·2	114·5	85·1	72·7	79·5	74·0	66·3	72·8	69·3	68·5	64·8	64·9
„ 10, 4 P.M.	125·5	77·8	70·0	115·8	79·1	69·2	84·5	72·7	68·8	73·0	70·0	69·2	65·6	66·0
„ 12, 4 P.M.	119·0	82·8	75·2	116·0	83·1	75·7	85·5	76·0	71·8	77·8	74·8	74·2	70·8	70·9
„ 13, noon	122·8	83·3	74·2	118·0	85·1	75·2	80·0	77·7	72·8	79·5	76·6	75·7	70·8	71·8
„ 13, 12.20 P.M.	124·2	83·8	75·2	120·0	86·1	76·2	83·0	78·0	73·3	80·5	77·3	76·7	72·3	73·1
„ 13, 1.20 P.M.	122·0	84·8	76·4	117·0	86·3	77·7	86·0	78·3	75·0	80·0	77·8	77·0	73·0	73·7
„ 13, 3.25 P.M.	129·0	87·6	78·7	123 2	87·6	79·2	92·0	80·3	76·8	83·5	79·8	79·1	75·0	75·0
Mean of 10 observations...	123·20	83·80	74·39	118·98	84·87	75·20	82·52	75·68	71·71	77·92	74·59	73·90	70·24	70·45

that the aneroid fell to about 28·85 in., and remained so for about 2 hours, though it "pumped" more than a tenth of an inch; this must, I suppose, have been between 7 and 9 A.M. of the 1st.

Ship 'Ardgowan,' Lat. 7° 59′ N., Long. 89° 2′ E. Wind S. by W. 5. Barometer 29·91*. "Gloomy weather with hard squalls."

Diagram 1.



With this diagram before us, and considering the cyclonic theory of hurricanes, it will be seen that the centre of this one had just passed to the northward of the 'Orontes,' having a westerly, or probably north-westerly route; for the wind had changed from N.W. to W. by S; and if the lowest pressure be a sufficient guide, it was much closer to her at 8 A.M. of the 1st than it was to Madras at 8 A.M. of the 2nd; for the 'Inverness's' lowest pressure was then 29·266 in., whilst the 'Orontes's' mercurial barometer was 28·87 in. at 8 A.M. of the 1st.

The 'Ardgowan' being at a great distance to the south-eastward, was experiencing the south-westerly wind, which would be expected to remain with a ship which had an area of low pressure passing away to the north-westward of her. This same south-westerly wind continued with the 'Orontes' until she got into Trincomalee on the 3rd, and in that port on the 4th.

I will now get the reader to turn to Diagram 2, on which are plotted the following data for noon of May 2nd.

May 2nd, Noon.

Ship 'Inverness.' Madras Roads. Wind E.N.E., 11. Barometer 29·383 in.

The Madras Observatory gives the following observations:—Wind S.E., speed 36 miles an hour. Barometer 29·373 in. Temperature about 80°·5 F.†.

* The reading of this barometer is doubtful.

† We have already remarked that the lowest pressure at the Observatory was at 8 A.M. The following are the records for that hour:—Wind N.E., speed 53 miles an hour. Barometer 29·287 in. Temperature about 76° F.

At the same time (8 A.M.) the 'Inverness' had wind N.E., 12. Barometer 29·266 in.

H.M.S. 'Orontes,' Lat. 9° 30′ N., Long. 81° 46′ E. Wind S.W., 4 to 6. Aneroid Barometer 29·670 in.

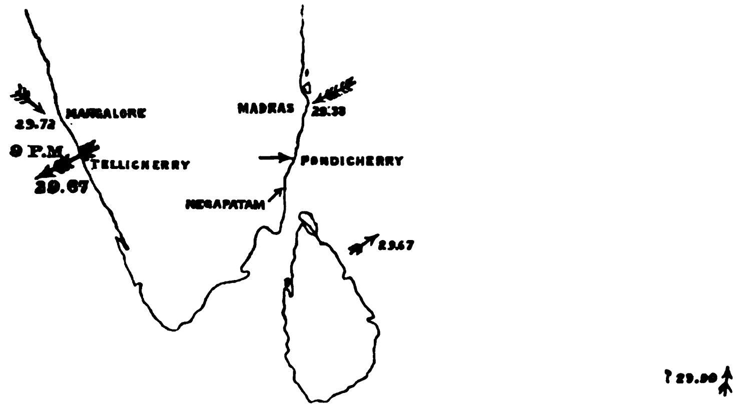
Ship. 'Ardgowan,' Lat. 7° 14′ N., Long. 90° 16′ E. Wind S., 3. Barometer 29·990 in.*. Weather fine.

May 2nd, 11.30 A.M.

S.S. 'Durley' leaving Mangalore, Lat. 12° 52′ N., Long. 74° 49′ E. Wind W.N.W., 6. Barometer 29·721 in.

This ship, leaving Mangalore at 11.30 A.M. of the 2nd, had a fresh W.N.W. wind and dirty weather; but she got the worst wind and weather off Tellicherry, Lat. 11° 45′ N., Long. 75° 28′ E., about 8 to 9 P.M., when it was N.E., 11, for about an hour, with almost incessant forked lightning, thunder, and very heavy rain. The wind then backed round from N.E. to N., N.W. and W., reaching S.W. by 2 A.M. of the 3rd. (See extract from log.)

Diagram 2.



From the data of May 1st we find that the area of lowest pressure, or centre of the cyclone, was nearest to H.M.S. 'Orontes' about 8 A.M. of the 1st, and that it passed to the northward of that ship, or the wind would not have backed from N.W. to W. and S.W.

From the data of May 2nd we learn that the area of lowest pressure was nearest to Madras about 8 A.M. of that day, and that it passed to the southward of that port, or the wind would not have veered from N.E. to E. and S.E.

We also know that H.M.S. 'Orontes' experienced the lowest barometer; hence we may conclude that the centre passed nearer to her than it did to Madras.

The changes of wind with the S.S. 'Durley' near Tellicherry were very irregular, as might be expected when we consider that a cyclone was probably passing or expending itself on the eastern side of the mountains forming the Western Ghauts. It will be noticed that the worst weather off Tellicherry took place about 12 hours after the lowest pressure passed Madras.

* The reading of this barometer is uncertain.

From the above scanty number of facts it seems fair to conclude that the centre of this cyclone passed to the westward, and probably to the north-westward, between the parallels of 10° and 13° N.; that its route was probably much interfered with by the high land to the W. and S.W. of Madras; but that it caused very disturbed weather on the west coast of India.

A careful consideration of Plate V., by the Assistant-Astronomer at Madras, leads to the conclusion that the first decided indication of the approach of the cyclone to that port took place *after* 10 P.M. of May 1st, at which hour the barometer had risen more than 0·04 in. since 4 P.M., the result of diurnal range. From 10 P.M. on the 1st to 8 A.M. on the 2nd it fell nearly three tenths, *i. e.* from 29·583 in. to 29·287 in., and no diurnal range was shown between these hours.

When we consider that ships leaving Madras Roads with a north-easterly wind and high sea must stand to the south-eastward and make much leeway, it is manifest that had they done so at 10 P.M. of the 1st they would have gone towards the centre of the cyclone, got the wind stronger, and more and more easterly, making the coast a dead lee-shore; so that the remark of Capt. Donkin, of the 'Inverness,' which ship rode out the cyclone, seems to be fully borne out, viz.:—"Had the ships slipped their cables at midnight of the 1st, they would have anticipated their fate."

Since writing the above, the Report of the Astronomer of Madras, published in the 'Nautical Magazine' for September 1872, has been brought to my notice; and a paper on the same subject by the First Assistant-Master Attendant at Madras has been sent in to the Office.

I do not see any thing in either to lead me to change the opinion already expressed. If, as the Astronomer says, the cyclone first travelled N. by W. and then W., of which there is no proof in his Report, captains of ships could not be expected to know beforehand that it was going to take this erratic course; and even if it did, and they had known its intention, one cannot see how they were to hope to be able to run to the southward between it and the land. It is manifest that, with a north-easterly wind drawing to the eastward, no ship from Madras could have passed to the eastward of the cyclone.

The second paper alluded to supports the opinions I have ventured to express. From it I learn that on May 1st the wind was north-westerly at Pondicherry in Lat. 11° 56′ N., Long. 79° 49′ E., and also at Negapatam in Lat. 10° 46′ N., Long. 79° 51′ E; whilst on the 2nd it was westerly at Pondicherry and south-westerly at Negapatam; the exact hours and force are not given, though no doubt it was blowing hard. These winds are represented on Diagrams 1 and 2.

This paper makes out that the cyclone travelled first westerly in about 10° N., and then about N.W. by N., until its centre struck the coast at Sadras, a point about midway between Madras and Pondicherry, where, unfortunately, no observations were taken.

It remarks on the fact that telegraphic communication from the coast

was unfortunately broken, so that the Master-Attendant had not the advantage of knowing what was going on elsewhere. This was certainly most unfortunate; but the paper seems quite to agree in supposing that the most perfect information would not have justified sending the ships to sea from the Madras Roads.

It states that ships which went to sea from Pondicherry and Negapatam were dismasted or lost, whilst those which remained at anchor rode out the gale; also that the one ship which did put to sea from Madras has never been heard of since; and that as she was driven directly towards the centre of the cyclone, it is most probable that she foundered in it.

Considering that ships in port are very rarely in a fit state for going to sea (the very fact of their being engaged in discharging or taking in cargo proving that they cannot be in trim), great judgment should be exercised in ordering them to "slip and run."

It is well known that Madras does not deserve the name of a port, and that it is not a fit place for ships to take in and discharge cargo during the hurricane months; still, if it is decided to have ships there at those times, they ought (when signs of a cyclone appear) to shift to the outer anchorage, where there is good holding-ground in blue mud, and a truer sea than there is near the shore.

No doubt the 'Inverness' and 'Bonnie Dundee' rode out the gale in consequence of their being in this favourable position.

During the night of the 21st of October, 1864, a fortnight after the great Calcutta cyclone, I rode out a similar one to the eastward of the entrance of the Hoogly: we anchored in 13 fathoms blue mud, and gave the ship a whole cable before the gale came on: the force of the wind was so great that the top-gallant-masts, with no yards on them, were blown away without my knowing it (though I stood on deck at the time), until a flash of lightning showed me that they were gone. This was in the same 'Hotspur' which was lost in the Madras cyclone—a fate which I venture to think she would have escaped had she been anchored further from the shore.

It is, however, due to captains that it should be known that ships *must* go near the shore in Madras if they wish to communicate; for boats will not take cargo &c. to them at the distance of the 'Inverness' and 'Bonnie Dundee.' The former had taken her position for throwing out ballast, which is not permitted nearer to the shore; and the latter was not in the port at all.

The conclusion one arrives at is, that when there are signs of a cyclone in Madras, each ship should be requested to take up a clear berth in 10 or more fathoms, to veer a good scope of cable before the wind freshens to a gale, and to devote all spare time to making snug, and preparing to put to sea if thought best. Any ship preferring to go to sea *at once* might of course do so.

A few words on the cause of this and other cyclones may not be out of place here.

From noon of the 29th April (Plate V.) Madras had been experiencing north-easterly winds; whilst during the same time the 'Ard-

gowan,' in about Lat. 9° N., and Long. 87° E., had strong and squally southerly winds: now, as Buys Ballot's law requires that an area of low pressure must have existed between these two winds, into which they were blowing, there can be little doubt that this was the breeding-place of the cyclone, and that the collision between these counter-currents of air caused the eddy or cyclone which was formed at their point of contact.

This same meeting of two currents of air seems to account for the north-easterly winter snow-storms of America, which are in close contact with, and form part of, cyclonic movements, having southerly winds on their eastern sides. (See Official No. 13, published by the Meteorological Office.)

It seems also worthy of notice that our researches into the weather of the Equatorial Doldrums in the North Atlantic show that at the time of year when West-India hurricanes take place, an area of high atmospheric pressure has pressed its way across the Equator as far as Lat. 10° or 12° N.; it is also known that at the same time there is another and higher pressure in about Lat. 30° N.; between these is an area of low pressure into which a south-westerly wind is blowing from the southern high pressure, and a north-easterly wind from the northern; also, the sun going to the southward, is drawing the whole system of wind to the southward, so that where south-westerly winds were blowing north-easterly winds are coming; and there can be little doubt that the collision between these two counter winds, in such close contact, cause the eddies which are the commencements of our West-India hurricanes. Mr. Meldrum finds a similar cause for the Mauritius hurricanes.

I am sorry this paper is not more complete; but the subject is so important that it seems right to call public attention to all available data, even though it is only fragmentary.

[H.M.]S. 'Orontes,' Captain J. L. Perry, R.N., from Penang to Negapatam.

1872.		Wind.		Barometer corrected.	Thermometer.		Weather.	Remarks.
[Day] and	Hour.	Direction.	Force.		Dry.	Damp.		
				in.	°	°		
...	8	N.W.	3–5	29·582	80·1	79·0	c. q. r.	8.30 A.M. Anchored 2½ miles off Negapatam lighthouse, in 5½ fms. Increasing easterly sea. No communication with the shore. A queer moaning sound in the wind with heavy gusts at times.
	10	N.	2–4	29·591	79·6	79·0	o. q. r. l.	
	Noon	N. by W.	2–4	29·557	78·6	78·0	o. q. r. l. t.	
	2	N. by W.	4–5	29·547	78·6	78·0	o. q. r.	2.15 P.M. Wind and swell increasing; shifted berth to 11½ fms., weather looking very bad, small vessels going to sea.
	4	N. by W.	5–6	29·547	78·6	78·0	o. q. r.	
	6	N.W.	4–6	29·496	77·2	77·1	o. q. r.	
	8	N.W.	7–8	29·532	78·1	78·0	o. q. r.	5.20. Proceeded to sea. Course E.N.E.
	10	N.W. by N.	8–7	29·509	78·1	78·0	o. q. l. r.	
	Midnight	N.N.W.	6–8	29·445	79·1	78·5	o. q. r.	10. Heavy sea from eastward.
.....	2	N.	6–8	29·150	78·7	78·6	o. q. r. l.	4 A.M. Hove to with easy steam under main and mizen trysails.
	4	N.	8–10	29·056	78·6	78·5	o. q. r. l.	7.50. Sea washed away jolly-boat from the stern.
	6	N.	8–11	28·900	78·1	78·0	o. q. r. l.	
	8	N.W.	in	28·870	78·1	78·0	o. q. r. l.	11. Sea and wind took jib from the bowsprit.
	10	W.N.W.	sudden	*29·15	78·1	78·0	o. q. r. l.	Noon, position 10° 12′ N., 81° 19′ E. Sea very heavy and broken, but not so destructive as the N. Atlantic sea.
	Noon	W. by S.	gusts.	29·25	78·1	78·0	o. q. r. l.	
	2	W. by S.	10–11	29·28			o. q. r.	2 P.M. Wore ship.
	4	W. by S.	10–11	29·26	No	use,	o. q. r.	5.15 Carried away main trysail mast. Hove to *without steam* under mizen trysail, and main trysail laced to main mast.
	6	W.S.W.	10–11	29·35	bulbs	con-	o. q. r.	
	8	W.S.W.	10	29·35		stantly	o. q. r.	
	10	S.W.	8	29·45		wet.	o. q. r. l.	
	Midnight	S.W.	9	29·46			o. q.	
.....	2	S.W.	9–7	29·45			o. q.	2 A.M. Heavy sea from south-westward.
	4	S.W.	7–8	29·47			o. q.	
	6	S.W. by S.	5–6	29·51	79·1	77·0	b. c. q.	Noon, position 9° 30′ N., 81° 46′ E.
	8	S.W. by S.	6	29·57	80·9	78·0	b. c. q.	Communicated with a barque, having her mizen and part of her fore-mast standing, she did not require assistance.
	10	S.S.W.	4	29·60	79·1	79·0	b. c. q. p.	
	Noon	S.W.	4–6	29·67	82·6	81·0	c. q. p.	

'Inverness,' Captain Thomas Donkin, R.N.R., anchored in Madras Roads.

......	Noon	N.Ely.	6	29·567	Noon. Observed signal at the Master Attendant's Office—"Surf impassable." 4 P.M. Set sea-watch. Towards evening squally weather, heavy showers, wind coming in gusts. Veered to 90 fathoms.
			to		
	4	N.Ely.	7	29·577	8 P.M. Secured everything about the decks &c. for bad weather. Close reefed topsails, foresail, and lower staysails ready for setting. Midnight, heavy squalls and heavy rain.
	Midnight	N.Ely.	8	29·527	
......	2	N.E.	9	29·436	Daylight, very heavy squalls, and very threatening appearance; waited for a lull and paid out to 130 fathoms of chain, letting go second anchor before doing so, and veering to 35 fathoms.
	4	N.E.	10	29·375	
	4.15	N.E.	11	29·343	About 5.30 A.M. observed the 'Burlington' drifting, about 7 A.M. the 'Ardbeg' drifting. 9 & 10 A.M. 'Sir Robert Sepping' dragging. 'Invereshie,' 'Hotspur,' 'Kingdom of Belgium,' 'Armenian,' 'Mary Scott,' and other country ships parted. At 11 A.M. the wind began to veer easterly, and knowing then that the centre was passing south (though very close) felt convinced that if the chain only held on another hour we should be safe. The ship did not drag at all; we were prepared to cut away should she have commenced. During the morning the sea was fearfully heavy, and now and then the head of a sea came on board, but no large body of water.
	8	N.E.	11·5	29·266	
	9	N.E.	12	29·267	
	9.30	N.E.	12	29·288	
	10	N.E.	11·5	29·306	
	10.30	N.E.	11	29·319	
	11	N.E. by E.	11	29·331	
	Noon	E.N.E.	10·5	29·383	
	1	E. by N.	10·5	29·413	I consider that neither the appearance of the weather, nor the indications of the barometer, before midnight on Wednesday the 1st, gave warning of a cyclone, and that had the ships slipped their cables then, they would have anticipated their fate.
	2	E.	9	29·446	
	2.30	E. by S.	9	29·453	
	3	S.E.	8	29·467	
	3.30	S.E. by S.	8	29·479	
	4	S.S.E.	7	29·481	
	4.30	S. by E.	7	29·501	
	5	S. by E.	6·5	29·541	
	6	S. by E.	6·5	29·548	
	7	S. by E.	6·5	29·550	
	8	Sly.	6	29·618	Wind decreasing to a light air towards morning of 3rd.

* [The] aneroid barometer went down as low as 28·85 and remained for two hours. All subsequent readings are from the aneroid, which was adjusted to the mercurial barometer before the gale.

S. S. 'Durley,' Captain R. D. Lunham, bound from Bombay to Tellicherry.

May 1st. Noon. Barometer steadily falling; swell increasing and weather looking very unsettled.

May 2nd. 11.30 A.M. Left Mangalore Roads, bound for Tellicherry. Steamed down the coast with fresh W.N.W. breeze and considerable sea. Barometer 29·721 in. still falling; dark, heavy masses of cloud working up from westward, and passing over, with slight increase of wind occasionally.

7 P.M. About seven miles W.N.W. of Tellicherry, barometer 29·684 in. Dark threatening appearance rapidly increasing all round, and heavy rain beginning to fall.

7.30 P.M. After a short lull of ten minutes, the wind sprung up again from N.W. and veered rapidly round by N. and E., making a complete circuit of the compass in about 15 or 20 minutes; arriving again at N.W.; it remained steady at that point for a few minutes, and then shifted suddenly and violently to N.E., blowing with intense fury for one hour—force 11, remaining tolerably steady at the same point, and accompanied all the time by very heavy rain and almost incessant forked lightning and thunder. The darkness also was intense, increased doubtless in appearance by the vividness of the lightning and the luminous appearance of the sea. The electric current appeared to come up from the westward, and pass immediately over the ship in the direction of the high land, at rather more than a right angle from the direction of the wind, then taking a south-easterly direction as if, when reaching the Ghauts, it had passed down parallel to them.

At 8 P.M. the ship's head had been put round to S.W., before the wind, and steamed off the land—barometer 29·664 in. Soon after this it began slowly to rise, at 9.30 P.M. it was 29·674 in., at midnight 29·705 in. 9 P.M. the wind and rain began to decrease, backing round to N., N.W., and finally at 2 A.M. on the morning of the 3rd it reached S.W. 10.30 A.M., 3rd, anchored in Tellicherry Roads.

Up to and including the evening of the 4th of May the weather continued very unsettled and threatening, occasional sharp squalls of wind and rain about sunset and sunrise, and very heavy surf on the beach.

The discussion on this paper will be found at p. 174.

XXIII. *On the Character of the Storm of the 21st–23rd of August, 1868 over the British Isles.* By Captain T. O. WATSON. (Communicated by R. H. SCOTT, F.R.S.)

[Received February 1, 1873. Read February 19, 1873.]

(Abstract.)

THE author refers to the 'Report on the Use of Isobaric Curves' by Captain H. Toynbee, F.R.A.S., and the data quoted are from that work. He considers the gale which passed over the British Isles on the 21st, 22nd, and 23rd of August, 1868, to have commenced at Valentia about

10 A.M. on the 21st, the S.E. quadrant of the gale approaching from the N.N.W., the wind at the gale's circumference being S.W. there. This wind, backing toward the S.E. until about 8 P.M., would seem to indicate that the path of the gale was directed to the S.S.E. The wind afterwards, veering from S.E. to S.W., and increasing in force as it became more westerly, indicates that the gale was moving then in a more easterly direction; and the fall of the mercury that its centre was approaching Valentia. Between 3 and 4 A.M. on the 22nd the centre passed north of Valentia, and between 4 and 5 P.M. on the same day it passed south of Liverpool. These facts, together with the long continuance of E.S.E. wind at Liverpool (whilst the wind was from N.W. and N.W. by W. at Valentia), do not accord, the author asserts, with the cyclone theory as at present understood.

The gale commenced at Valentia about August 21st, 10 A.M.; the central wind shifted there about August 22nd, 3 A.M., which give for the elapsed time 17 hours.

The gale commenced at Liverpool, 21st, 10 P.M., wind S.S.E. The central wind, which shifted at Valentia on 22nd at 3 A.M., shifted at Liverpool at 4 P.M. the same day; so that the elapsed time was 13 hours.

But, considering the retardation caused by the curve of the gale's path and 29 minutes gained by difference of longitude in passage, it may be presumed to have made the distance in 12½ hours. The distance between Valentia and Liverpool being 281 miles, the speed of the gale on its onward path was about 22½ miles per hour. The interval of 17 hours between the commencement of the gale and the central shift of wind at Valentia, multiplied by 22½ miles, its onward speed, gives 382½ miles for its radius, or 765 for its diameter.

Again, the lowest barometrical pressure at Valentia occurred at 2½ A.M. of the 22nd, and at Liverpool at 2 P.M. of the same day; so that the elapsed time was 11½ hours. This gives the approximate diameter of the gale 770 miles. This cannot be far from the truth; for on the 22nd, at 8 A.M., the gale appears to have been limited on the south near Rochfort, and on the north near Aberdeen. The centre had passed Roche's Point, where a heavy gale was blowing from N.N.W., while Cape Grisnez had the S.S.W. wind of the gale's eastern edge; a distance little over 300 miles. Biarritz, Lyons, and Strasburg appear to have been beyond its limit.

The author has constructed a circular diagram to trace out the gale's progress upon a map, having the wind-arrows upon it deflected towards the centre one point in every seven equal divisions of the radii; and he thinks that in great hurricanes the winds will deflect eight points from circumference to centre. Hence he maintains that the revolution of gales is only apparent, as the wind blowing may have the opposite bearance of the gale's centre blowing right into the vortex.

The wind had much less velocity at Valentia than at Liverpool; this, and the difference of the barometrical readings, 29·11 in. at Valentia and 29·06 in. at Liverpool, prove the centre to have passed some distance

north of Valentia. The wind, flying from E.S.E. to W.N.W. at Liverpool, and remaining steady for so great a length of time, shows that the gale was still travelling in an easterly direction, and the W.N.W. wind near the centre was accelerated by the speed of the gale being added to its velocity.

The author states that the study of this gale confirms his practical experience; and that, as regards extent and the wind's deflection, it represents the gales of the northern hemisphere. He concludes by asserting that he forwards his views as another link towards completing the chain of attempts to demonstrate winds and their mode of operation.

The discussion on this paper will be found at p. 175.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 15th, 1873.

Ordinary Meeting.

John W. Tripe, M.D., President, in the Chair.

John Coley Coley Bromfield, 38 Russell Square, Brighton; Rev. John Byron, M.A., Killingholme Vicarage, Ulceby; John Delaney, Postmaster-General, St. John's, Newfoundland; James Kennedy Esdaill, B.A., Saint Hill Place, East Grinstead; Rev. Thomas Felton Falkner, B.A., St. Thomas's College, Colombo; William Humber, 20 Abingdon Street, Westminster; John Johnson, The Larches Cottage, Wigan Lane, Wigan; Rev. William Clement Ley, M.A., Breinton Vicarage, Hereford; and Frederick J. Marriott, Perry Hill, Sydenham, were balloted for, and duly elected Fellows of the Society.

The names of three Candidates for Admission into the Society were read.

The following papers were then read:—

"On Solar Radiation." By the Rev. Fenwick W. Stow, M.A., F.M.S. (p. 187).

The President said that the Society was much indebted to Mr. Stow for his paper, and agreed with him that comparatively little is known about solar radiation. He could speak personally as to the scorching power of the sun in mountainous regions, and especially above the line of perpetual snow, apparently arising partly from the dryness of the air and partly from the reflection of the sun's rays from the snow.

Mr. Strachan, with the President's permission, read the following extracts from a memoir in the 'Journal of the Franklin Institute' for December 1872, by J. M'Clure, C.E.:—"When the thermometer stood at 60° in the shade, I placed another in the sunlight and found its temperature to be 80°;" . . . . "on placing this thermometer within a glass shade, and again exposing it, the temperature rose to 98°, notwithstanding that a considerable portion of the sun's heat must have been arrested by the glass; the limit, however, was not yet reached. I enclosed a thermometer in a small test-tube, and packed the space around the bulb with iron-filings; this test-tube was then enclosed within another, containing at its lower end a small quantity of iron-filings, and insulated from contact with it by means of plungers of cotton wadding; this was placed within a third similarly prepared tube, and the whole arrangement deposited in a glass case and exposed to the sunlight. The mercury rose slowly and almost uniformly until it attained a temperature of 195°. Again I placed a single flat glass case, containing my thermometer, on the top of a metal plate, beneath which a lamp was burning; the thermometer indicated, in the sun, a temperature of 166°. When a screen was interposed it sank to 126°, and afterwards rose to its original temperature, 166°, on the removal of the screen. I then raised the lamp until the thermometer showed 180° in the shade. The additional heat produced by the uncondensed sunlight raised the mercury to

the limit of my thermometer, 212°. That is, as the temperature of the air increased, or, what is the same thing, its convection-capacity diminished, the heating-power of the sun's rays seemed also to increase. In fact, as far as my experiments went, the sun's rays produced in any dark-coloured solid a temperature of from 10° to 40° above that of the air by which it was surrounded, and the higher the absolute temperature of the air the greater seemed to be the difference between sun and shade."

"The sun and earth stand to one another in the relation of electrified bodies" . . . . "If heat is developed on one half of the earth's surface in consequence of that surface being electrified, then it is reasonable to suppose that cold should result on the opposite hemisphere, where the complementary electricity is induced. If, during the day, heat is developed most copiously in bodies with rough surfaces, in bodies on which a high degree of induction can be produced, then, during the night, cold to a corresponding extent should be developed in the same bodies" . . . . "Following out these hypotheses to their legitimate conclusion, we should expect to find recurrence of similar seasons in all the planets at those periods during which the elements of the solar system occupy the same relative positions in space. We should expect to find that when the sun's rays strike vertically on any portion of the earth, producing intense heat, cold to a corresponding extent should be developed on that space where the rays produced intersect the surface of the opposite hemisphere. We should expect to find the mean temperature of the earth at aphelion several degrees higher than at perihelion." The statement of the last sentence ought, it would seem, to be reversed. The experiments appear so remarkable, that it was to be hoped that some meteorologists in this country would repeat them, as we were yet far from having attained a satisfactory mode of measuring solar radiation. Trifling variations in size and construction of the black-bulb thermometers gave rise to great differences in their indications under similar circumstances, which were perplexing.

Mr. Symons was much obliged to Mr. Strachan for the extracts he had read; but the results seemed to be what were to be expected from the conditions described. In the helio-pyrometer of Mr. Southall the thermometer went above 212°; and Col. Ward's apparatus boiled water, and this without the intervention of any thing but a clear slab of plate glass. He thought that Mr. M'Clure's thermometer must have had a bright bulb, but when put into iron-filings it became black. The Society was much indebted to Mr. Stow for his paper and facts, which proved that there are many puzzling things in solar radiation. Reference had been made to the effect of height above the ground; it was not perhaps sufficiently known that, when placed with their bulbs 4 feet above grass, solar-radiation thermometers were strictly comparable, and would give very good results. It was very desirable to compare the thermometers both in sun and shade. Mr. Stow was gradually extending his stations over the globe, instruments having been sent to South America, Greece, and Ceylon. It was most desirable to establish them in all latitudes, because solar intensity did not follow the same rules as air-temperature; for instance, he believed, Scoresby mentioned that, in the Arctic regions, pitch was melted on the side of the ship exposed to the sun, while intense frost prevailed on the other side of the ship.

Mr. Scott said that the highest observed solar temperature of which he had heard was 215°, at Leh*, in Ladakh; but not unfrequently, in Thibet, observations had been taken, ranging above the boiling-point of water for the height of the place.

Mr. Eaton asked whether solar thermometers were affected by the wind.

Rev. F. W. Stow replied that the bulb could only be affected to the same extent as the outer jacket, the temperature of which was never more than a few degrees higher than that of the air, if the instrument was placed at 4 feet. It was, therefore, practically unaffected by wind; but this was not the case if the instrument was placed on the ground.

Mr. Park Harrison asked whether Mr. Stow had observed solar radiation to be increased by clouds in the neighbourhood of the sun.

Rev. F. W. Stow said that the conclusions he had come to on that point were expressed in his second paper.

Mr. Symons referred Mr. Stow to a paper by Mr. Vernon, in the 'Manchester Memoirs,' on "Black-bulb Solar-Radiation Thermometers exposed in various media."

* Report on Meteorological Observations in the Punjab for 1867, by Dr. A. Neil, p. 17.

Rev. F. W. Stow said, in reply to Mr. Strachan, that it was well known that if thermometers were enclosed in two glasses, higher temperatures were obtained, as the rate of cooling was much slower. He thought that Mr. Symons had given him credit for enterprise which was in a great measure his own.

"On Temperature in Sun and Shade; an account of Experiments made at Harpenden, Herts." By the Rev. Fenwick W. Stow, M.A., F.M.S. (p. 146).

The President thought the present a good time to decide upon the form of stand to be used by observers, as the results recorded at different stations must be modified to a certain extent by the stand used. Also that the objects to be obtained by observations should be as far as possible determined upon before the form of stand is settled.

Mr. Scott said that the question of the exposure of thermometers had formed one of the most important subjects of deliberation at the Leipzig conference, and it was hoped that a comprehensive report on the actual modes of exposure at present in use would be submitted to the proposed Vienna Congress. The diversity which is found in the modes of exposure was very serious. Thus, the Prussian mode was to use a screen on a north wall, at a height of at least 12 to 15 feet. In Switzerland and Russia a screen somewhat like Lawson's was used. In France M. Deville placed the thermometers under a sloping roof, at a height of about 10 feet from the ground, and surrounded them on the east, south, and west by evergreen trees. In Italy the "finestra meteorologica" was used, which was an opening on the north side of the house. Some of the observers in cold countries had absolutely declined to give up the practise of reading from a window. It was therefore evident that meteorologists were very far from having at all a uniform practice in the observation of temperature.

Mr. Symons said that he was responsible for the delay of the Strathfield-Turgiss experiments; he hoped the Editing Committee would get Mr. Stow's paper out as soon as possible, as it would be useful in discussing the Strathfield results. He thought there were reasons why the height of the stand above the ground should be 10 feet. Reference had been made to radiation from heated ground in the tropics; but it must not be forgotten that in the Arctic regions the amount of radiation is very great.

Dr. Mann stated that during an experience of several years at Natal he found that thermometers in open isolated stands could not be relied upon, but that with a louvre-board stand on the south wall of the house and under a broad verandah he got good results; in seven years the mean temperature of each year, deduced from observations with this arrangement, did not vary to the extent of half a degree Fahrenheit.

Mr. Gaster said he could not allow Mr. Symons to take so large a share of the blame as he had done for the delay of the Strathfield-Turgiss experiments. It might be possible to complete his portion of the work in about three weeks. There is a great need of such a series of observations like Mr. Stow's, in order to explain several discrepancies. As to the height of the thermometers above the ground; supposing, with Dove, that 12 feet be taken as the regular height, then a fall of snow, say of 5 feet, would reduce the height, *pro. tem.*, by that amount. He believed that *single louvre-board* screens freely exposed to solar rays were a snare and delusion; he had compared single and double louvre-board screens, and thermometers in the single ones got much overheated.

Mr. Dinks said it appeared from the paper that in order to secure uniformity in every respect it was necessary to have the same kind of stand, and that the bulbs of the thermometers should be of the same shape and size.

Mr. Godsman suggested that the observations should be laid down in curves, and then proceed by successive approximations, as used in astronomical observations. Mr. Raper had rendered Nautical Astronomy an exact science by the mode in which he had pointed out the limits of accuracy and degree of dependence to be placed upon the observations and methods of reduction employed. A copy of his book was in the Library of the Institution of Civil Engineers, and a perusal of his method of treating the general question of observations and their reduction would repay the student in any cognate science.

Mr. Strachan considered that the allusion to nautical astronomy made by the last speaker was not quite to the point, inasmuch as that is an exact science, while meteorology is an experimental science. In nautical astronomy probable errors of data could be dealt with by the differential calculus, and limits of accuracy,

n results sought, could be deduced. With meteorology the difficulty was to obtain formulæ expressive of the data. Wherever this could be done, as, for instance, for phenomena of periodicity, a proper series of observations could be formulated, and the most probable value could therefrom be deduced for any time. The same thing might be done by the graphic method of laying down curves with less labour, and also less accuracy. The formula, in fact, gave a curve without accidental irregularities, or rather with those irregularities smoothed down. But with such mixed series of observations as must have been made for comparing so many different forms of screens, it was not easy to see how the graphic method could be applied, and perhaps the previous speaker would suggest how it could be done. Would Mr. Stow state what he considered the best size and form of louvre-screen for general use on land and on shipboard, and whether or not Stevenson's screen was protected from radiation from the ground?

Rev. F. W. Stow thought that thermometers in Stevenson's screen were, to a great extent, protected from radiation from the ground by the fact that its width was less than its height, and the thermometers were very close together. He thought Mr. Gaster was very hard on single louvre-board screens; he had devised one which had been recently tried at Strathfield Turgiss, and gave maximum temperatures closely approximate to those in the large Kew double screen. The thermometers should not be placed too near the louvre-boards; a double roof is required, which should project so as to keep the sun off. The form is not very important if certain conditions are fulfilled; he had at present a small square screen fixed on a pole 20 feet above the ground, and one of a different shape at 4 feet, both appearing to give good results. He had no objection to placing thermometers 10 or 12 feet above the ground, except the inconvenience of having to use a ladder. He did not think it wise to put the thermometers on the north side of a house, as the range is very much diminished in such a position.

Mr. Gaster did not think he had seen any results from the stand mentioned by Mr. Stow.

Rev. F. W. Stow said the fact was he had devised two stands, the former of which was, as he now thought, on a bad principle; but the high temperatures which it gave served to show the extent of radiation from the ground.

Mr. Gaster remarked that there was very little louvre-board in Mr. Stow's stand at all.

"Remarks on the 'Pocky' Cloud observed July 27th, 1872." By J. S. Harding, F.M.S. (p. 154).

"Account of the Hurricane which passed over the Nichol Bay district of Western Australia on March 20th, 1872." By R. J. Sholl, Government Resident (p. 155).

"Extract from Log of Barque 'Lady of the Lake.'" By Capt. Frederick William Banner (p. 157).

The Meeting was then adjourned.

February 19th, 1873.

Ordinary Meeting.

John W. Tripe, M.D., President, in the Chair.

John Knox Laughton, M.A., F.R.A.S., Royal Naval College, Greenwich; Rev. Alexander Mackennal, B.A., Town Museum, Leicester; and James Nicol, M.D., Warwick House, Llandudno, were balloted for and duly elected Fellows of the Society.

The names of seven Candidates for Admission into the Society were read.

Mr. W. R. Birt and Mr. J. S. Harding were appointed Auditors of the Accounts.

The following papers were then read:—

"Description of an Electrical Self-registering Anemometer and Rain-gauge." By the Rev. Fenwick W. Stow, M.A., F.M.S. (p. 157).

The PRESIDENT said the Society was much indebted to Mr. Stow for the valuable papers which he had brought before it; and he expressed his admiration of the model exhibited.

Mr. WALKER thought the idea was good. Very little power is wanted to move the coil to produce each current in Wheatstone's A, B, C telegraph instrument; but the motion must not be too slow.

Mr. SYMONS was glad to see that Mr. Stow had gone back to the principle of Crossley's gauge; and was inclined to believe that for self-registering rain-gauges, the only reliable mode was by tipping-buckets. He wished to know if Mr. Crossley's apparatus had been in practical use; if it would only work, it would be useful. He believed Mr. Crossley had several instruments of that class; but he wished to know if long-continued records had been obtained from any of them.

Rev. F. W. STOW said that he could not answer that question with regard to the little registering machine on the table; but he understood that the electro-magnetic apparatus had been worked with success.

Mr. STRACHAN stated that a description of Crossley's electrical anemometer with Breguet's apparatus appeared in the 'Mechanics' Magazine' about four years ago (the date is 1868, Oct. 4). He believed that the error of registry in Beckley's rain-gauge arose from the capillary action of the mercury in which the receiver is floated, which determined a difference of absolute level, or line of floatation, according as it was sinking with the weight of water or rising after its discharge.

Mr. HALL thought that with regard to the reversing screw (although admitting it to be a very ingenious arrangement), it would be found on examination that a loss of motion in the pencil occurred at either end of the screw, in the act of reversion—a matter of serious consequence, more especially in low velocities.

Mr. SCOTT asked if Mr. Stow thought his rain-gauge could be made to register mechanically without the use of electricity.

Rev. F. W. STOW said he thought that a mechanician would have no difficulty in making the tipping-bucket work an escapement, and so drive a spiral pencil upon a revolving cylinder, the motive power being obtained from a spring.

Mr. CATOR observed that he had inspected the instrument last October, and that it seemed to him to be very useful, and the best instrument he had seen for showing small movements of the air, but that the recording-paper would not allow of gusts being shown. He thought a good deal of time and trouble would be necessary to read the results from the trace and reduce them to figures.

"On the Madras Cyclone of May 2nd, 1872." By Capt. H. Toynbee, F.R.A.S. (p. 160).

The PRESIDENT said that Capt. Toynbee's paper started new ground; and thought that it was well to pay attention to the practical results to be obtained from meteorology. The paper was important as showing that several captains had been unjustly blamed for not going to sea, whilst the path of this, as well as of some other storms there, was adverse to their doing so.

Mr. STRACHAN said he had read many accounts of hurricanes, but very few were attended with such valuable practical results as Capt. Toynbee had put forth. Selecting only well-authenticated data he gave thereon an important practical lesson, a method which it would be well to follow in other discussions of storms.

Mr. SYMONS asked if Capt. Toynbee had read the letters in 'The Times' about this storm. As to its path, it seemed that there was a change in the direction, the writer in 'The Times' made it start from Trincomalee and travel nearly up to Madras, where it changed to a westerly course, which would lead towards Tellicherry, and as the town of Vellore was greatly damaged by the reservoir giving way, it probably was near the centre of the track of the storm, which would rather corroborate the view of the writer in 'The Times.'

Capt. TOYNBEE said that he had seen the letters referred to; but he thought the storm took the coast-line.

Mr. SYMONS remarked that he had been informed that the anemometer at Madras was a very bad one; certainly the damage was excessive for a wind of the velocity reported.

Mr. SCOTT said that the fact alluded to by Mr. Symons, as to the track of the storm having been determined by the coast-line, was not an uncommon phenomenon. It had already been noticed by Piddington in the case of the cyclone of June 1839 in the Bay of Bengal, which had been deflected from its course by the Arracan Mountains and had swept the valley of the Ganges. This storm had been

cited by Dove in his 'Law of Storms.' In the case of our own storms it sometimes happened that they skirted the west coast of Ireland or Scotland for a time, and then crossed over to the North Sea. As regarded the velocity recorded at Madras having been only about fifty-three miles an hour, he had made some inquiry into the circumstances, in order to ascertain whether or not the force of the wind during the cyclone in question was, or was not, greater than the force of some of the storms on the coasts of these islands. One of the gentlemen whose observations had been quoted in the paper, Capt. Donkin of the 'Inverness,' had been out in the Channel in the storm of Nov. 22, 1872, when the 'Royal Adelaide' was lost on Cheeil Beach, and had been blown back, hove to, from the Lizard to the Casquets, and had then put into Portland. As the Meteorological Office had been mistaken about this gale, and had issued orders to lower the drums on the south coast at noon on Friday the 22nd, the weather at that time showing little signs of disturbance, he (Mr. Scott) had written to Capt. Donkin to ask him whether or not the gale had taken him by surprise, and also, whether or not the force of the wind had been at all equal to that felt during the Madras Cyclone. Capt. Donkin's reply had been that the gale had come on quite unexpectedly, and as regards the force of the wind, his words were:—"It is my opinion that for two hours only at Madras, on the 2nd of May, did it blow harder than on Friday night, and then only to a small amount, whereas the force of wind on Friday night, Saturday, and Saturday night for thirty-six hours, was almost that of hurricane strength." Capt. Donkin reported force 12 in his log; but the maximum velocity recorded at Falmouth Observatory was only fifty-seven miles an hour. So far, therefore, this evidence corroborated the figures for Madras; but as at Falmouth a velocity exceeding seventy miles an hour had been registered more than once, it was evident that the indications given by anemometers on land could not be taken as exactly showing the force of the wind at sea; for if fifty-seven miles an hour corresponded to force 12, the highest figure of Beaufort's scale, it was sufficiently clear that to the velocity of seventy miles, there must be a much greater force to correspond. The fact was, in his opinion, that special corrections were required for all anemometers on land, and he hoped by a comparison with the records at the Eddystone Lighthouse to be able to determine such corrections for Falmouth, which would show the retardation of the wind for each point of the compass. In the case of Yarmouth, where the anemometer had been erected on a perfectly level line of coast, the retardation of the west wind as compared with the east wind amounted to no less than one half, when the records of the anemograph on the Sailor's Home were compared with the Log of the Lightship at St. Nicholas Gat, 1¼ mile from the shore, for the loan of which the Meteorological Office had been indebted to the Elder Brethren of the Trinity House.

Rev. F. W. Stow observed that on the east coast of Yorkshire he had found that gusts were more frequent with west winds. This would make the ratio of estimated force to velocity higher than in the case of east winds.

Mr. Lecky stated, in confirmation of the wind blowing in narrow strips, that last August twelvemonth, when on Woolwich Common, he witnessed a little tornado among leaves. The leaves were first seen curling round and round, but the cyclone or tornado gradually increased so much in strength, that it took a little boy off his feet and blew him into a ditch. The strip appeared to be very narrow, and was just 100 yards from where he stood in comparatively calm air.

Mr. Southall, having tracked a local tornado, in July last, in the form of a ˥_, suggested that such might have been the case in the Madras cyclone, and that thus the apparently diverse statements as to direction might be reconciled.

Mr. Gaster said that for fifty-three miles an hour to be the maximum velocity for an East-India hurricane was simply monstrous; smoke in London, driven by wind, might be seen travelling much faster on some occasions.

Mr. Strachan said what Mr. Gaster had said with reference to smoke was better illustrated by balloons. Mr. Glaisher, in his balloon ascents was often carried at a rate per hour many times exceeding the velocity of the wind at the Observatory, and the great velocity of the upper air-currents was a subject of common observation by aëronauts.

"On the Character of the Storm of 21st–23rd of August, 1868, over the British Isles." By Capt. T. O. Watson (p. 168).

Mr. Gaster said that he had drawn many hundreds of isobaric curves, and had found the rotatory motion of the wind was more clearly marked near the centre of

the depression than at its outer margin, whereas in the somewhat fanciful diagram exhibited the contrary was shown.

Mr. STRACHAN said he had examined this paper, and that, if he understood the diagram aright, Capt. Watson supposes the gale to have maintained the same dimensions for three days, which is contrary to reason and experience. Then, again, it was equally erroneous to suppose storms exhibit a symmetrical circular shape. The chief feature of Capt. Watson's theory is the hypothesis of the incurvating paths of the winds. Buchan and others maintain that the winds of storms blow spirally towards the centre. But Capt. Watson makes the winds blow dead into the calm region. Places near to and on opposite sides of the vortex are shown to have wind-arrows directed towards each other, whereas, according to received notions they should be parallel and opposite in direction. There does not seem any impossibility in this part of the theory; and it would be well to make it a subject of inquiry, because if there be any truth in it the long-used rule for finding the bearing of the centre would not apply when well into the storm. Moreover, if the winds incurvated in any such way, the law correlating winds with isobars would not hold good for the greater part of the area of storms. The particular case appeared to be supported by the data quoted, probably because attention is only directed to two or three stations, making the gale begin and end at Valencia. It might be useful to try the method against the facts of some other storms. The path assigned to the storm by Capt. Watson agrees with that deduced by Capt. Toynbee; and there is a peculiar analogy between the variations in the direction of the wind along any radius from the storm's centre, as laid down by Capt. Watson, and the changes in direction of the Trade Wind as defined by Capt. Toynbee. Commencing about lat. 30° N., where the barometer is high, the wind is easterly. As we go southward it becomes north-easterly while the pressure is decreasing; and when we arrive at the edge of the equatorial calms, where the pressure is lowest, the wind is northerly. Similarly with the south-east trade-wind. Capt. Watson, with an easterly wind in the northern part of the storm's periphery, maintains that further into the storm on the same bearing, the wind gets more to the north-east, and, finally, near the vortex it becomes northerly. Similarly, for a south wind at the boundary he gives an east wind near the centre, on the same radius. This analogy is curious and interesting. Probably the true state of the case is not represented by the theory either as applied to the trades or to storms, but it may help us on in our researches for the truth. It will probably be allowed that it is very difficult to ascertain with precision as to time and direction the wind near a storm's centre. At all events, it is only fair, where there is so much uncertainty, that different views should have a fair hearing.

The Meeting was then adjourned.

CORRESPONDENCE AND NOTES.

We have again to notice a complete reorganization of the Meteorological System in France.

The following is a translation of the decrees and regulations relating to the Observatoire:—

"Article 1. The study of the great movements of the atmosphere, and the meteorological warnings to the ports and agricultural districts, are placed among the duties of the Observatory of Paris.

"Article 2. The investigations relating to the general physical geography of the various river-basins of France are assigned to the Local and Departmental Commissions, of which the Council of the Observatory is authorized to carry out the organization.

"Article 3. The Meteorological Observatory at Montsouris is erected as an independent establishment for the Department of the Seine.

"Article 4. The Minister of Public Instruction, Religious Worship, and Fine Arts is authorized to carry out the present decree.

"Done at Versailles, February 13, 1873. "A. THIERS.

"To carry out this reform the following have been nominated:—

"Director of the Observatory at Paris, President of the Council of that establishment, M. Le Verrier, Member of the Academy of Sciences and of the Bureau des Longitudes.

"Councillors of the Observatory:—

"MM. Belgrand, Member of the Academy of Sciences, Inspector-General des Ponts et Chaussées.

"Fizeau, Member of the Academy of Sciences.

"Vice-Admiral Jurien de la Gravière, Member of the Academy of Sciences, Director of the Depôt des Cartes et Plans de la Marine.

"Janssen, Member of the Academy of Sciences.

"Tresca, Member of the Academy of Sciences, Sub-Director of the Conservatoire des Arts et Métiers.

"Daubrée, Member of the Academy of Sciences, Director of the School of Mines.

"Article 2. The following are nominated Members of the Council:—

"MM. Yvon Villarceau, Member of the Academy of Sciences, Astronomer at the Observatory, Secretary of the Bureau des Longitudes.

"Wolff, Astronomer at the Observatory.

"Gaillot, Assistant-Astronomer at the Observatory.

"Rayet, Assistant-Astronomer at the Observatory.

"M. Marié Davy is nominated Director of the Observatory at Montsouris, which is erected as an independent establishment for the Department of the Seine, the study of the great movements of the atmosphere and the meteorological warnings to the ports and agricultural districts being placed among the duties of the Observatory of Paris.

"M. Stephan, delegated to the direction of the Observatory of Marseilles, is nominated Director of that establishment."

M. Le Verrier has not as yet resumed his post at the head of the Observatory; and the 'Bulletin International' is still (April 1873) dated from Montsouris.

M. C. Ste Claire Deville remains Inspector-General of Meteorological Stations.

The Meteorological Institute has been established in Sweden, a step which was announced as probable at page 114 of this Journal. Professor Robert Rubenson is nominated to the Directorship; and the central office is situated at Stockholm.

Donations received from January 1st to March 31st, 1873.

Presented by Societies, Institutions, &c.

Brisbane	General Registry Office ...	Twelfth Annual Report of the Registrar-General, on Vital Statistics, 1871. By H. Scott, Registrar-General.
Brussels	Académie Royale	Annuaire, 1872, 1873.
	"	Bulletins, 2ᵉ série, tomes 31–34.
	"	Centième Anniversaire de Fondation, tomes i., ii.
	Observatoire Royal	Annales, Nov. and Dec. 1871, Jan. 1872.
	"	Observations des Phénomènes Périodiques, 1870.
	"	Notices extraites de l'Annuaire de l'Observatoire pour 1873. By M. Ad. Quetelet, Director.
Calcutta	Meteorological Office	Abstract, 1868–71. By H. F. Blandford, Government Meteorological Reporter.
Copenhagen ...	L'Institut Météorologique Danois.	Observations at various stations, Oct. 1872 to Feb. 1873. By N. Hoffmeyer, Director.
Cracow	K. K. Sternwarte	Meteorologische Beobachtungen, December 1872. By Dr. F. Karlinski, Director.
Fiume	I. R. Academia di Marina...	Meteorological Observations, Nov. and Dec. 1872.
Kew...............	Observatory	Report for the fifteen Months ending October 31, 1872. By the Kew Committee.
London	Art Union	Report of the Council, 1872.
	London Institution	Journal, Nos. 18, 19.
	Meteorological Office	Daily Weather Report and Charts.
	"	Quarterly Weather Report, 1871. Part ii. 1872. Part ii.
	"	Report of the Proceedings of the Meteorological Conference at Leipzig. By the Meteorological Committee.
	Royal Astronomical Society	Memoirs, vol. xxxix. Part ii.
	Royal Society	Proceedings, No. 140–142.
Manchester......	Literary and Philosophical Society.	Proceedings, Dec. 24th, 1872, to Feb. 18th, 1873.
Newcastle	Tyneside Naturalists' Field Club.	Meteorological and Climatological Register. By Rev. R. F. Wheeler, M.A.
Paris	Observatoire National	Annuaire Météorologique, 1873.
	" "	Bulletin International.
	" "	Bulletin Mensuel, December 1872.
	Société Météorologique de France.	Annuaire, 1869, tableaux météorologiques, feuilles 1–4.
Rome	Osservatorio del Collegio Romano.	Bulletino Meteorologico, vol. xi. no. 12; vol. xii. nos. 1 & 2.
	" "	Le Stelle Cadenti del 27 Novembre 1872; nota del P. Angelo Secchi.
	" "	Nota Spettroscopiche sul Sole e gli altri corpi celesti del P. A. Secchi. By Padre Secchi, Director.
Stonyhurst	Observatory	Meteorological Report, 1860–64.
	"	Results of Meteorological and Magnetical Observations, 1866–72. By Rev. S. J. Perry, M.A.

Sydney	Observatory	Meteorological Observations made at the Government Observatory, Sydney, September 1872. By H. C. Russell, B.A., Government Astronomer.
Toronto	Education Office	Journal of Education, November to December 1872. By Rev. E. Ryerson, D.D.
Victoria	General Registry Office ...	Patents and Patentees, vol. v. By W. H. Archer, Registrar-General.
Vienna............	K. K. Centralanstalt für Meteorologie und Erdmagnetismus.	Beobachtungen, November and December 1872. By Dr. C. Jelinek, Director.
	Oesterreichische Gesellschaft für Meteorologie.	Zeitschrift, Band vii.
	" "	Bericht über die Verhandlungen der Meteorologen-Versammlung zu Leipzig.
Wellington	General Registry Office ...	Statistics of New Zealand, 1871. By J. B. Bennett, Registrar-General.

Presented by Individuals.

Bazerque, Capt.	La caravane universelle.
Casella, L. P., F.R.A.S.......	Catalogue of Scientific Instruments.
Celoria, G.	Sul grande commovimento atmosferico avvenuto il 1 di Agosto 1872 nella Bassa Lombardia e nella Lomellina.
Delaney, John	Mean Meteorological Results for a period of eight years (1857–64) from the Observations of the late Mr. E. M. J. Delaney, at St. John's, Newfoundland.
"	General Meteorological Register at St. John's, Newfoundland, for the year 1872.
Higgs, Rev. W., M.A.	'Telegraphic Journal and Electrical Review,' vol. i. Nos. 4, 5.
Molesworth, Sir Paul William	Meteorological Journals of the late Miss Caroline Molesworth, of Cobham, 1825–67. (MS.)
Nelson, R. J.	Summary of Meteorological Observations made at Kendal during 1872.
Prettner, Dr. J.	Meteorologische Beobachtungen zu Klagenfurt, Dec. 1872.
Prince, C. L., F.R.A.S.	The Climate of Uckfield.
Sawyer, F. E.	Earthquake Shocks in Sussex.
"	The Rainfall of Sussex.
"	Meteorology of Brighton, 1872.
"	Summary of Meteorological Observations for 1872, at 55 Buckingham Place, Brighton.
Schiaparelli, G. W., and Denza, P. F.	Sulla grande pioggia di stelle cadenti prodotta dalla cometa periodica di Biela e osservata le sera del 27 Novembre, 1872.
Symons, G. J.	'Symons's Monthly Meteorological Magazine,' Feb. and Mar. 1873.
"	Quarterly Return of the Registrar-General of Scotland, June 30 and Sept. 30, 1872.
"	Monthly statement of Rainfall at stations on the Manchester, Sheffield, and Lincolnshire Railway, 1872.
The Editor	'Food Journal,' Nos. 36–38.
"	'Nature,' Nos. 166–178.
Walker, C. V., F.R.S.	American Journal of Science and Art, January 1843 to January 1847.
" "	Transactions of the American Philosophical Society, vol. ix., and celebration of the hundredth anniversary.
" "	Annual Reports of the Cornwall Polytechnic Society, 1833–42, 1844–45.
" "	Annali di Fisica, Chimica e Matematiche, vols. i.–xiv.
" "	Il Cimento Giornale di Fisica, Chimica e Storia Naturale, November 1844 to December 1846.

Walker, C. V., F.R.S.	Nieuwe Verhandelingen der Eerste Klasse vat het Koninklijk Nederlandsche Institut, vol. xiii.
" "	Tydschrift voor de Wis- en Natuurkundige Wetenschappen 1849, part 3.
" "	Instructions pour l'observation des Phénomènes Périodiques.
" "	Observations des Phénomènes Périodiques, 1841–46, 1848.
" "	Nouveau Catalogue des Principales Apparitions d'Etoiles Filantes (Quetelet, 1841).
" "	Sur le Climat de la Belgique, 1845, part 1.
" "	Mémoire sur les tremblements de terre dans le bassin du Rhin (Perrey).
" "	Mémoire sur les tremblements de terre en France, en Belgique et en Hollande (Perrey).
" "	An Essay on Terrestrial Heat, being the first chapter of the Elements of Meteorology, by M. Pouillet (MS.).

QUARTERLY JOURNAL

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XXIV. *On some Results of Weather Telegraphy.*

By ROBERT H. SCOTT, F.R.S.

[Received March 19, 1873. Read March 19, 1873.]

THE popular idea of Weather Telegraphy appears to be that reports from a number of outposts are received at a central station, and that the person charged with the duty of discussing the information is able to deal with the collection of observations so received with the same confidence as if he had taken the readings himself and had a perfect knowledge of the entire character of the weather at each locality. It is hardly requisite to remark that the above is very far from being the real state of the case. The reports are necessarily sent in a condensed form in order to save expense, and the choice of situation of the several stations has been, perforce, ruled by many considerations besides mere suitability for affording unexceptionable information.

In this latter connexion I may mention that we have found that if a telegraphic observer has not a fair amount of constant telegraphic work to do he will very probably neglect his meteorological duties. Thus we have had to give up certain stations, as Portrush, because the reports were constantly bad, owing to the incorrigible idleness of the observer. The very best stations we have are those which are also signal-stations for the Mercantile-Marine Code, where the observer is on constant duty, day and night, on an exposed part of the coast.

This necessity of choosing stations shows us that the position of the instruments is seldom entirely satisfactory, and that the reports of Wind and Sea are often untrustworthy for certain points of the compass.

Even though the information were sufficient, both in quantity and quality, to give us a good idea of the instrumental readings over the

country, it is quite impossible to get a complete account of the general conditions of the weather at each place in a telegram short enough to be transmitted at a fair cost.

Again, it is needless to say that more frequent telegrams are required; and here, again, is a source of expense. In fact, the idea of a constant watch to be kept at all the more important stations is simply impracticable on the ground of cost.

The regular weekly interruption of our weather study on Sundays is a most serious matter for the perfect efficiency of our system; but as long as the Post-office arrangements for Sunday remain unchanged it appears needless to insist on attendance at the Office on that day, when the results of our studies could not be transmitted to the parties interested in obtaining them.

In the United States the system of Weather Telegraphy is conducted on a far more extensive scale than in these islands; while we, for our part, are far in advance of all other European states. The Signal Office at Washington receives 3 reports a day at equidistant hours from about 80 stations; while we have, or should have, did the reports arrive punctually, 46 reports in the morning and 9 at 2 P.M. It is a fair question whether or not the cost of the American system as compared with our own is not excessive. The grant from Congress to their service is $250,000 for last year; while we spent hardly one fourteenth of that sum, viz. £4000.

I have not yet alluded to one of the most serious obstacles to the development of a perfect system of weather telegraphy. This is the frequency of telegraphic errors. In this connexion I do not merely speak of the foreign reports; for the Society can easily understand that a report from Corunna, passing through French and English offices, where the clerks are innocent of Spanish, is often all but unintelligible. It is the errors in our own reports which are the great trouble to us. Of these errors, great and small, there were, during the year 1872, about 300 which were traced, though we did not formally report more than one fifth of this number, to the Post-office by letter. Many of these errors arise from the fact that our code consists mainly of figures, in the transmission of which mistakes are especially likely to arise. These mistakes in telegraphy, as well as the delays in transmission, are, unfortunately, more frequent at a period when the weather is disturbed than in time of calm; so that at the very moment that we are most in want of full information it is all but impossible to obtain it.

As an instance, admittedly a very exceptional one, I may cite the storm of February 6, 1870, the very day before which the transfer of the telegraphic business to the Post-office took place. *On February 5 we received by telegraph no P.M. reports at all!* We are unavoidably liable to a breakdown of nearly equal gravity whenever a serious storm, such as the snowstorm of February 2, 1873, sets in. For these defects, caused by *force majeure*, we cannot attach any blame to the telegraphic authorities.

Before leaving this part of the subject it may be well to place on record

ny conviction that it *is absolutely necessary that the reporters shall be under the direct control of the central discussing station.* Where this is not the case, as in some foreign countries, it has been found that the duty of reporting is not properly attended to, and in some cases there is great difficulty in having defective instruments replaced by good ones.

Admitting, however, that we possess a reasonable number of well-equipped stations, a good staff of observers, and that we enjoy a moderate freedom from telegraphic errors, the fact still remains that we have in these islands the most exposed district in Europe, except, perhaps, the north-west coast of Norway, and that we must do the best we can.

The idea of mooring ships or large buoys off our western coasts to form advanced posts of observation may be given up as sufficiently chimerical, at least until it has been proved to be practicable. It is an acknowledged principle with the Trinity House and the other two Lighthouse Boards, that no lightship or lighthouse can, with safety to life, be placed in any situation where it cannot be visited once a week at the least. It may safely be said that a vessel moored 100 or even 50 miles west of the Fastnet could not have been visited more than once or twice during the two months succeeding the middle of November last.

The idea of obtaining information from the United States is nearly equally visionary; for the whole phenomena of the storms change their character entirely in travelling over any considerable portion of the earth's surface.

Recently the Portuguese meteorologists, at the suggestion of Prof. Buys Ballot, have proposed to furnish observations from the Azores as soon as a cable shall have been laid from that group of islands to the mainland. This question was discussed at some length at the Meeting of the British Association at Edinburgh in 1871; and the Council of the Scottish Meteorological Society, in their Report to the General Meeting, July 4 of the same year, stated " there is no country which would benefit so much by this intelligence as Great Britain."

It being of great importance to test this statement thoroughly, I have requested Mr. Strachan, one of our Fellows, to compare the curves of daily readings from Angra do Heroismo and Valencia for the space of 2½ years; and I append his Report:—

"*Inquiry into the connexion of Atmospheric Disturbances at Valencia and Angra do Heroismo.*

" I have examined the diagrams of the barometer, prepared from observations made at Valencia and Angra during 1870, 1871, to the end of June 1872, and have counted 66 well-marked depressions or *minima* at Valencia, of which, apparently, 7 were shown two days before at Angra, 9 one day before, 5 on same day, 9 one day after, 6 two days after, 7 three days after, while 23 were not indicated there. As regards the well-defined elevations or *maxima* which occurred at Valencia during this period of 30 months, of which I have counted 45, apparently 8 were shown one day before at Angra, 3 two days before, 1 three days before,

8 on same day, 6 one day after, 4 two days after, 1 three days after; 13 were not indicated, and for one there was no comparison from hiatus in record.

"Thus out of 111 cases, it appears that only 28 were possibly indicated at Angra before, and as many as 33 after, they happened at Valencia.

"For the purpose of forewarning of British weather, any indications to be obtained from Angra ought to be from two to three days in advance; but it appears from this inquiry that such indications would only amount to 10 per cent. of the required number, and these of more or less doubtful precision. Instead of this comparison being favourable to Angra, as an outpost for indications of approaching weather for Western Europe, the result is altogether negative.

"It should also be remarked that the range of the barometer at Angra is seldom so large as at Valencia, and that some disturbances occur at Angra which are not apparent at Valencia.

"I have not been able to carry out any satisfactory comparison of the winds at these two stations. For such a purpose it would be better to represent the observations of the wind's direction and velocity by traces, in the same manner as for the barometer, instead of showing them by feathered arrows, as in the present diagrams.

"R. Strachan,
1873, 2, 12."

From this it is evident that there is, *primâ facie*, no reason for expecting that reports from the Azores would be of any service to us as giving direct intelligence of storms which are advancing on our coasts. In fact, as already noticed by Captain Toynbee in the 'Barometer Manual,' p. 31, there seems some reason to think that the trajectories of storms over that part of the Atlantic are directed from north-west to south-east (see 'Nautical Magazine,' 1842, p. 145). It may be of interest to the Society to know that when the communication with the Azores has been established we shall receive the reports, and shall, undoubtedly, derive considerable benefit from the daily knowledge of the conditions of pressure and wind over the district in which they are situated, though we shall not be actually warned for storms.

As regards our system of reports and warnings it is undeniable that our telegraphic code is more complete and satisfactory than any other in Europe, inasmuch as, besides giving the rainfall and hygrometric information, it enables us to make a barometrical chart for 6 P.M. with nearly the same accuracy as that for 8 A.M.

As to the warning messages to the coast stations they are necessarily very concise. Any idea of telegraphing gradients, or even barometrical readings, to uneducated fishermen at the present day, bears on the face of it unsuitability to the requirements which the warnings are mainly intended to meet, whatever hopes we may cherish of the future enlightenment of our sailors. It is true that at some stations, such as Whitby, the telegrams received are regularly discussed by the fishermen with the view

of eliciting from them the extent of danger to that part of the coast; but it is very seldom that such trouble as the above is taken.

The mode of conveying the information to the public is a matter which requires serious attention. On the one hand we must be careful not to interfere with existing signals for harbour purposes, and on the other we must provide that the signals are sufficient to indicate our meaning.

Admiral FitzRoy's use of the drum and cones has, in my opinion, been rather misunderstood by myself as well as other people. The two cones indicated equatorial or polar *gales* respectively, while the drum indicated "*stormy winds* from more than one quarter successively." As far as I can learn, the Admiral did not necessarily mean *a storm* by the words *stormy winds*; he originally considered the drum as a signal for coasters and small craft, while the cones were employed to announce danger for larger seagoing ships. In the woodcut of the signals, however, the signification of the drum is given as "*gales successively*."

It is well worth considering whether or not such a system is desirable. One serious difficulty with which we have to contend is that the hoisting of any signal is too often taken as an excuse by seamen for refusing to go to sea; so that the ship-owners, as a body, protected by insurance, do not care for our signals. Had we a graduated system of signals we should certainly issue warning messages more frequently, and the complaints of interference with navigation would be more serious, besides the danger of too often repeating the cry of "Wolf!" "Wolf!" In fact, in the opinion of many men who are well competent to judge, and are not ship-owners, such as our lamented Honorary Member, Commodore Maury, our warnings should only be issued when a storm of exceptional violence is expected. In answer to this suggestion I shall only say that we shall be heartily glad when the perfection of our theoretical knowledge enables us to form beforehand a reasonably correct anticipation of the violence of any great number of our storms.

The only country in which Admiral FitzRoy's signal system is now employed is Portugal, where the authorities resolved to adopt it just at the time when it was given up in this country.

As is well known, the meaning of our present signal is that a telegram has been received, and every one must go to learn what the news is.

Two plans have been proposed for conveying the intelligence to ships passing or at anchor, as at the Downs or in Yarmouth Roads. One was devised by my colleague, Captain Toynbee. It consisted of a semaphore with two arms, one to show the part of our coast on which a storm was blowing, and the other to show the direction of the wind. This system was tested during the year 1868 at Blackwall, Liverpool, and North Shields; but it was not found advisable to adopt it, as the seafaring public would not take the trouble to understand it.

The other plan has been employed in Holland for several years, and by it the direction and amount of the most important gradient is shown. The instrument is called the Aëroklinoscope, and consists of a bar slung by the centre like a ship's yard, but capable of being turned in any azimuth

and of being peaked to any angle. The practical difficulty in the use of this plan is that it is very hard to read it if you do not face it exactly, for you cannot be quite certain which end of the arm is the nearer to you.

My own impression as to the form of signal is, that we shall probably either abide by the drum, or revert to the use of the drum and cones in a signification somewhat similar to that which they had in Admiral FitzRoy's time.

While speaking of the mode of giving intelligence to seaports I may be allowed to make some remarks on the difficulty of issuing warnings to Collieries at any reasonable expense. Our Office has been considered to have taken up this question in 1868, and then to have let it drop. The real reason that it was let drop was that the Home Office declined to take any part in the issue of such intelligence; but even if the Government had given their sanction to the plan it would have been a costly proceeding to carry it into execution, owing to the fact that no signals could be used, the collieries being spread over a wide tract of country in each district.

I now come to the comparison of the telegraphic intelligence issued by us with the facts observed; and this is not so easy a matter as it seems. In fact the attempts which we made to obtain a record of weather from the Coastguard Stations showed us how unsatisfactory had been the tests applied to Admiral FitzRoy's system. We found that reporters at adjacent stations constantly contradicted each other as to the hour of commencement, and even the direction and force of the gale. This was chiefly owing to the difference between the exposures at the several stations. Thus while a southerly gale was blowing at Holyhead, a place like Conway, under the lee of high land, enjoyed a moderate breeze.

I need not here enlarge further on my remarks at the last Meeting on the difficulty of drawing conclusions as to the force of the wind at sea from observations made at land observatories. It is evident, therefore, that the greatest care is requisite in order not to arrive at false results.

In former statements of the results of the warnings we may say, speaking *very generally*, on the one hand, that favourable results were found whenever it was considered that the occurrence of a storm at one station on a coast-line justified the warning; and, on the other, that unfavourable results were obtained whenever it was considered that if there was one station on the coast-line where the gale did not occur the warning was a failure.

It is evidently hopeless to reconcile such very different conceptions of the mode of testing. For our part we have considered that the existence of a gale on a coast-line required evidence from two independent stations; and as we have not got such stations on the north-west coast of Ireland and the west coast of Scotland, we have excluded those districts from our consideration.

I append herewith the condensed Tables for the last three years, of which the first has already been printed in the form of a Parliamentary Return (No. 504, 1871). The figures show in the first two years a percentage of gales foretold of 46, and in the year 1872 this rises to 61. In each year there are about 20 per cent. of warnings which were justified by the occurrence of strong winds, though not by gales: these we count

Table I. (1870.)

	Total No. of orders to hoist and repetitions.	Warnings justified by subsequent gales; force 8 and upwards.	Warnings justified by subsequent strong winds; forces 6 and 7.	Warnings not justified by subsequent storms.	Warnings late; force 9 reached at two stations before issue.	Warnings partially late; force 9 reached at one station before issue.	Warnings late, owing to Sundays or telegraphic errors.	Storms for which no warning was issued.
h	42	23	3	6	3	5	2	Jan. 3, Feb. 6 s, Mar. 23 p, Oct 15 s, Nov. 9 p.
....	47	18	16	11	...	...	2	Feb. 6 s, Oct. 15 s.
t	31	10	3	14	1	2	1	Jan. 31 s, Feb. 6 s, May 19.
t yde).	42	13	9	14	...	3	3	Jan. 31 s, Feb. 6 s, Feb. 14 s, Oct. 15 s, Dec. 18 s.
th-west	47	27	11	8	...	...	1	Feb. 6 s, Oct. 15 s.
t	43	27	9	2	...	2	3	Feb. 6 s, Feb. 27 s, Oct. 15 s, Oct. 22 s, Oct. 31 s.
th	40	20	11	7	...	...	2	Feb. 27 s, Oct. 15 s, Oct. 31 s.
th-east	30	11	7	12	...	...	...	
......	27	14	7	4	1	1	...	
....	349	163	76	78	5	13	14	
tages...	...	46·7	21·8	22·4	1·4	3·7	4	

Table II. (1871.)

h	34	13	3	7	3	4	4	Jan. 9 p, Feb. 19 s, Oct. 27, Oct. 29, Dec. 27.
....	37	19	4	9	1	2	2	Jan. 15, Feb. 19 s, Oct. 27, Dec. 27.
t	30	14	8	7	...	...	1	Jan. 16 s, Mar. 7 p.
t yde).	36	11	8	14	...	1	2	Jan. 16 s, Feb. 19 s, Feb. 22 p, May 3 p, Aug. 20 s, Oct. 27.
th-west	38	17	7	6	...	5	3	Jan. 15, Feb. 20 s, Aug. 20 s, Oct. 27, Nov. 17 p, Dec. 1 p, Dec. 28.
t	36	24	5	3	2	1	1	Jan. 15, Jan. 16 s, Oct. 1 s, Oct. 29, Dec. 28.
th	37	19	7	3	3	4	1	Jan. 15, Jan. 16 s, Mar. 16 p, Oct. 29.
h-east	23	11	3	8	...	1	0	Jan. 16 s, Dec. 1.
......	29	10	8	9	...	2	...	Jan. 16 s, Dec. 1.
....	300	138	53	66	9	20	14	
ages...	...	46	17·7	22	3	6·7	4·7	

Table III. (1872.)

1	48	23	10	6	1	7	1	April 2 p & 21 s, Oct. 16 p & 23, Nov. 9 & 22, Dec. 22 s.
....	48	36	6	3	1	1	1	April 21 s, May 3, Oct. 16 p, Nov. 9 p.
......	30	18	5	5	...	1	1	Jan. 3 p, April 16 p, Oct. 4 p.
t rde).	43	16	16	10	...	...	1	April 16, Sept. 28.
h-west	49	34	7	3	3	1	1	April 21 s, Sept. 28, Oct. 23, Nov. 9, Dec. 22 s.
......	47	40	4	1	1	1	...	Nov. 21.
h	61	35	17	6	1	2	...	April 2, Nov. 22.
h-east	25	15	4	4	...	2	...	Jan. 4, April 21 s, Dec. 8 s.
......	28	14	5	7	...	2	...	Jan. 4 p, April 8 s, Nov. 9, Dec. 16.
....	379	231	74	45	7	17	5	
ages...	...	61	19·5	11·9	1·8	4·5	1·3	

as successes, and thus the total percentage of success in the three years respectively is 68, 63, and 80. This last figure is slightly higher than that which was obtained in the office for Admiral FitzRoy's warnings, and is, of course, far higher than that given in the Report of the Committee appointed to consider the condition of the office on Admiral FitzRoy's death.

The Signal Office of the United States claims 76 per cent. of success for its warnings; and I think that we may say that our result for last year of 80 per cent. of storms and strong winds occurring after the hoisting of the drum is a fact on which we have just reason to congratulate ourselves.

It should be remembered that in analyzing the reports "all observations of the wind in which the force exceeded 7 (a moderate gale), or the velocity exceeded 40 miles an hour, have been quoted as instances of the occurrences of a gale; but it has not been considered that the drum was hoisted *late* or was *hauled down too soon,* unless the force of 9 (a strong gale), or the velocity of 50 miles an hour, was reached *prior* to the issue of the order to hoist or *subsequent* to the issue of the order to lower."

In the summary, all cases in which the signal has been shown to be partially late by one single report of force 9, or of the velocity of 50 miles, have been specially noted in the remarks, and marked with a *p*.

All telegrams which were late, owing to the intervention of Sundays or telegraphic errors, are marked with *s*.

The discussion on this paper will be found at p. 219.

XXV. *On the Barometric Depression of January 24th,* 1872.

By William Marriott, Assistant Secretary.

[Received March 19, 1873. Read March 19, 1873.]

On the morning of January 24th, 1872, a remarkable depression of the barometer took place all over England, and at several places the pressure was observed to be below 28·2 in. As the barometer seldom falls below 28·7 in., it obviously becomes a matter of some importance to have a full record of so exceptional a case. A great deal of interest in such a rare phenomenon was felt by many observers, and general attention was also drawn to it on account of the storm which accompanied it.

A short notice of this depression appeared in the 'Meteorological Magazine' for February 1872, in which Mr. Symons briefly hinted at its probable outline and path; and in order that it might at some future time be more fully discussed, he requested that observers who had taken any barometric readings on the date in question would send a copy of them to him. At the Council Meeting in October last, Mr. Symons handed over to the Society all the records he had received, finding that undesirable delay would of necessity be caused if he attempted the discussion himself, and considering that the Assistant Secretary might advantageously be employed to complete the investigation.

A great many observations had been received, chiefly of the 9 A.M. readings, and but very few for the period most required, in consequence of the phenomenon occurring in the early morning. It has been deemed best to use in this discussion only the readings from self-recording barographs, standard barometers, and four others on which reliance can be placed. Table I. gives the readings of the barometer for each hour from

P.M. on the 23rd to 9 P.M. on the 24th; all readings are corrected for ıdex error, temperature, and height above sea-level. At several stations ıany observations beside those at the hour were taken; these are given ı Appendix I.

The depression seems to have first touched the English coast at or near 'almouth, and, as shown by the self-recording anemometer at that Observatory, to have passed over that town, the wind having backed from S. by :. at 9 P.M. on the 23rd to N. by midnight. Fig. 1 gives the isobars for ıidnight (p. 196). The lowest readings are at Falmouth 28·42 in. and t Plymouth 28·42 in. The direction of the wind at Falmouth being N., nd at Plymouth W.S.W., shows that the centre of the depression had just assed Falmouth in a north-easterly direction. The force of the wind, owever, was not great, about 15 miles per hour being registered at 'almouth; at Plymouth it was estimated at 3 (Beaufort scale), and was ıoderate from S.E. at Upwey, near Dorchester.

Fig. 2 shows the depression a little to the N.N.W. of Plymouth, he reading at that time (1 A.M.) being 28·319 in., with a west-southresterly wind of force 3. At Bodmin 28·30 in. was observed by an neroid; but it is not stated whether this is corrected for temperature nd reduced to sea-level. At Falmouth the reading of the barometer was 8·43 in., wind N.W., with a velocity of about 18 miles per hour; and t Upwey 28·37 in., wind S., rising.

By 2 A.M. (fig. 3) the depression had travelled in an east-north-easterly irection, and lay a little to the W. of Upwey, where the reading was 8·26 in., wind S., increasing. At Plymouth the barometer was 28·36 in., rind W.S.W., force 3. At Guernsey the observer states that "the ressure recorded by Osler's anemometer was 28 to 35 lbs. on the square ɔot, a velocity of 75 to 85 miles an hour, the wind veering from S.E. to .S.W.; at this hour (2 A.M.) the barometer read as low as 28·400 in." ıt Falmouth the reading was 28·49 in., wind W.N.W., with a velocity of bout 20 miles per hour; at Kew 28·53 in., wind E.S.E., with a velocity f 25 miles per hour; while at Stonyhurst the barometer was 28·59 in., rind E.N.E., with a velocity of not more than 5 miles per hour.

At 3 A.M. (fig. 4) the centre of the depression appears to have been very ear to Upwey, the reading at that place being 28·21 in., wind S.W., blowing furious gale. At Evesham the barometer was 28·376 in., and at Ross bout 28·38 in. At Ryde, Isle of Wight, a yacht's captain observed 8·3 in., and stated that "he thought house and all would be blown over ɔ the North Sea." At Worthing Mr. Harris observed 28·432 in., and ɘmarks that "after midnight the force of the wind increased; and between and 3 A.M. a heavy and strong gale from the S.S.W. was blowing, inreasing in power every minute. I recorded the lowest reading at 3 A.M. 'he gale still increased in violence, and appeared to reach its maximum bout 4 A.M., when the wind veered somewhat W."

At 4 A.M. (fig. 5) the centre of the depression seems to have been a ttle to the south of Bath; but the number of recorded observations is ısufficient to give the isobars with any thing like accuracy. At Evesham he reading was 28·26 in.; at Wilton, near Salisbury, 28·29 in.; and at Ross 28·30 in. At Kew the barometer was 28·34 in., wind S., velocity

Table I. Readings of the Barometer at each hour, from January 23rd,

Stations.	Observer.	January 23rd. 9.	10.	11.	January 24th. Midnight	1.	2.	3.
		in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+
Falmouth, Cornwall	Self-registering Barographs.	·65	·57	·48	·42	·43	·49	·55
Greenwich, Kent		·87	·86	·81	·75	·64	·53	·44
Kew, Surrey		·87	·84	·79	·73	·64	·53	·44
Birmingham, Warwickshire		...	...	...	·71	·66	·59	·50
Bidston, Cheshire		·68	·68	·67	·66	·62	·60	·57
Halifax, Yorkshire		·69	·70	·72	·71	·67	·64	·60
Stonyhurst, Lancashire		·67	·69	·68	·66	·62	·59	·56
Glasgow, Lanarkshire		·60	·59	·58	·56	·56	·55	·55
Aberdeen, Aberdeenshire		·79	·75	·72	·70	·64	·60	·60
London, Camden Square	G. J. Symons	·848	...	...	·730	·645	·541	·43
London, Regent's Park	W. Sowerby	·836	·81	·74	...	...	...	...
Upper Tooting, Surrey	D. A. Freeman	...	...	...	·750	...	...	...
Weybridge Heath, Surrey	W. F. Harrison	...	·843	...	...	...	...	...
Chiselhurst, Kent	F. Nunes	...	·853	...	...	...	...	·45
Crossness, Kent	F. Houghton	...	...	...	...	...	...	...
Tunbridge Wells, Kent	W. A. Smith	...	...	...	·82	...	...	·54
Beckenham (Parkside), Kent.	C. O. F. Cator	...	...	...	...	...	...	...
Beckenham (Foxgrove), Kent.	P. Bicknell	...	...	·82	·76	...	...	...
Forest Hill, Kent	E. E. Glyde	...	·87	·83	...	...	...	...
Worthing, Sussex	W. J. Harris	·866	...	...	...	...	...	·43
Brighton, Sussex	F. E. Sawyer	...	·838	...	·61	·518	...	...
Uckfield, Sussex	C. L. Prince	·885	...	...	...	...	...	...
Ventnor, Isle of Wight	J. B. Martin	...	...	...	...	...	...	...
Ryde, Isle of Wight	R. Taylor	...	...	...	...	...	...	...
Osborne, Isle of Wight	J. R. Mann	...	...	...	...	...	...	...
Bournemouth, Hants	T. A. Compton	...	...	...	...	...	...	...
Lymington, Hants	G. J. Jones	...	...	...	...	...	...	...
Southampton, Hants	Major-Gen. Sir H. James	...	...	·673	...	...	...	...
Strathfield Turgiss, Hants	Rev. C. H. Griffith	...	...	...	...	...	...	...
Selborne, Hants	T. Bell	·756	...	...	...	...	...	...
Harpenden, Herts	Rev. F. W. Stow	...	·826	...	...	...	...	...
Berkhampstead, Herts	W. Squire	·860	...	...	...	...	...	·433
Banbury, Oxfordshire	T. Beesley	...	...	...	...	...	...	...
Oxford, Oxfordshire	Rev. R. Main	·83	·810	...	...	...	...	...
Abington Pigotts, Cambridgeshire	G. Pigott	...	...	...	...	...	...	...
Wisbeach, Cambridgeshire	S. H. Miller	...	...	...	...	...	...	...
Colchester, Essex	Sergeant Sheehan	...	...	...	...	...	...	...
Saffron Walden, Essex	J. Bryan	·887	...	...	...	...	...	...
Sudbury, Suffolk	J. Alexander	·870	...	...	...	...	...	...
Somerleyton, Suffolk	Rev. C. J. Steward	...	...	...	...	...	...	...
Beccles, Suffolk	E. T. Dowson	·92	...	·89	...	...	...	...
Yarmouth, Norfolk	T. Robinson	...	...	...	...	...	...	...
Diss, Norfolk	T. E. Amyot	...	...	...	...	...	...	...
Norwich, Norfolk	C. M. Gibson	·869	...	...	...	...	...	...
Wilton, Salisbury, Wiltshire	T. Challis	·691	...	...	...	...	...	...
Upwey, Dorchester, Dorsetshire	J. Miller	·749	·67	·58	·49	·37	·26	·21
Maiden Newton, Dorsetshire	Rev. P. H. Newnham	...	·650	...	...	...	...	...

Note.—The readings given in Roman

9 P.M., to January 24th, 9 P.M. (reduced to sea-level).

	January 24th.																
–	5.	6.	7.	8.	9.	10.	11.	noon.	1.	2.	3.	4.	5.	6.	7.	8.	9.
n.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+
9	·63	·66	·68	·70	·72	·75	·77	·76	·75	·72	·72	·71	·70	·70	·68	·68	·69
8	·38	·39	·45	·56	·65	·70	·75	·78	·81	·84	·87	...	...	...	...	...	·96
4	·34	·37	·47	·57	·67	·74	·78	·79	·82	·84	·89	·92	·93	·94	·95	·96	·97
9	·31	·27	·31	·41	·50	·56	·61	·65	·66	·67	·69	·74	·76	·77	·78	·78	·78
2	·52	·51	·50	·50	·51	·52	·56	·58	·59	·61	·63	·64	·66	·66	·67	·68	·70
6	·52	·43	·38	·35	·37	·42	·47	·48	·56	·60	·63	·65	·68	·70	·72	·74	·76
3	·49	·46	·44	·43	·44	·47	·51	·54	·56	·60	·61	·63	·65	·67	·68	·70	·71
5	·56	·57	·58	·57	·57	·57	·57	·56	·55	·56	·57	·58	·59	·60	·62	·63	·64
0	·63	·64	·66	·66	·63	·61	·60	·53	·49	·47	·45	·44	·45	·46	·49	·52	·57
65	·345	·360	·420	·538	·616	...	·756	·769	...	...	...	...	...	...	...	...	·938
..	...	...	...	...	·616	...	...	...	...	...	·856	...	...	...	...	...	·926
..	...	·380	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·650	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·690	...	...	...	...	...	·905	...	...	...	...	...	...
502	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
40	...	...	...	...	·679	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	·598	·677	...	...	...	...	...	...	...	...	...	...	...	...
..	·38	...	...	·57	·65	·72	·77	...	·82	·86	...	...	·92	·92	...	·95	...
..	...	...	...	...	·746	...	...	...	...	...	·885	...	...	...	...	...	·974
..	...	...	...	...	·762	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·765	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·741	...	...	...	...	...	...	...	...	...	...	...	...
391	...	...	·604	...	·732	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·750	...	...	...	...	...	·890	...	...	...	...	...	...
..	...	...	...	...	...	·740	...	...	...	...	...	...	...	...	...	...	...
345	...	...	...	...	·737	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·694	...	...	...	...	...	·864	...	...	...	...	...	...
..	...	...	...	...	·663	...	...	...	...	...	...	...	...	...	...	...	·741
..	...	...	...	...	·590	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·610	·680	...	...	...	·808	...	...	...	·886	...	...	...
..	...	...	...	·42	·539	...	...	...	...	...	·758	...	...	...	...	...	...
..	...	...	...	...	...	·690	...	...	...	·758	...	...	...	...	...	...	...
..	...	...	...	...	·573	...	...	...	...	...	...	...	...	...	...	...	·986
..	...	...	...	...	·375	...	...	...	...	...	·759	...	...	...	...	...	...
..	...	...	...	...	·570	...	...	...	...	...	·927	...	...	...	...	...	...
..	...	...	...	·398	·526	...	...	...	...	...	...	...	...	...	...	...	·958
..	...	...	...	...	·560	...	...	...	...	...	...	...	...	...	...	...	·940
..	...	...	...	...	·473	...	...	...	...	...	·808	...	...	...	...	...	...
..	...	...	...	·40	·45	...	...	·66	...	...	·79	...	...	·90	...	...	...
..	...	...	...	·430	...	...	...	...	...	·769	...	...	...	...	...	...	...
..	...	...	...	...	·46	...	...	...	...	...	...	...	...	...	...	...	...
..	...	...	...	...	·397	·477	·565	...	·719	...	·798	·843	...	...	·930	·942	·951
293	...	...	...	...	·602	...	...	...	...	...	...	...	...	...	...	...	·782
...	...	...	·54	·64	·738	...	...	...	...	...	...	...	...	·850	...	...	·856
...	...	...	...	...	...	·690	...	...	...	...	...	...	...	...	...	...	...

pe have been interpolated.

TABLE I. (*continued*). Readings of the Barometer at each hour, from

Stations.	Observer.	January 23rd.			January 24th.			
		9.	10.	11.	Midnight	1.	2.	3.
		in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+
Ashburton, Devonshire	F. Amery	...	...	...	...	...	...	...
Sidmouth, Devonshire	J. I. Mackenzie	...	...	...	·489	...	...	...
Ilfracombe, Devonshire	W. Clark	...	...	...	...	...	...	...
Barnstaple, Devonshire	T. Mackrell	...	...	...	...	...	...	...
Plymouth, Devonshire	J. Merrifield	...	...	·537	·42	·319	·36	...
Truro, Cornwall	C. Barham	·724	...	...	...	...	...	...
Bath, Somersetshire	C. S. Barter	·514	...	...	...	...	...	...
Fairford, Gloucestershire	Rev. R. P. Davis	...	...	...	·640	...	...	...
Ross, Herefordshire	H. Southall	...	...	...	·64	·54	·46	·38
Breinton, Herefordshire	Rev. W. C. Ley	...	...	...	...	...	...	...
Woolstaston, Shropshire	Rev. E. D. Carr	·649	...	...	...	...	...	...
Evesham, Worcestershire	R. Burlingham	...	...	...	...	...	...	·376
Orleton, Worcestershire	T. H. Davis	·71	...	...	...	...	...	...
Wolverhampton, Warwickshire	J. Thrustans	...	...	...	...	...	...	...
Leamington, Warwickshire	S. U. Jones	...	...	...	...	...	...	...
Nottingham	M. O. Tarbotton	...	...	...	...	...	...	...
Derby, Derbyshire	J. Davis	...	...	...	...	...	...	...
Ripley, Derbyshire	P. Wright	...	·780	...	...	...	...	...
Appleby, Lincolnshire	Rev. E. J. Cross	...	...	...	...	...	...	...
Killingholme, Lincolnshire	Rev. J. Byron	...	...	...	...	...	...	...
Hinderton, Cheshire	R. Bushell	...	...	·684	...	...	...	...
Manchester, Eccles, Lancashire	T. Mackereth	·703	...	...	...	...	...	...
Manchester, Old Trafford, Lancashire	G. V. Vernon	...	...	·694	...	...	...	...
Manchester, Heaton Chapel, Lancashire	J. Curtis	...	·669	...	...	...	...	...
Caton, Lancashire	Rev. A. Christopherson	...	·677	...	...	...	...	...
Beverley, Yorkshire	T. Dyson	...	...	...	...	...	...	...
Scarborough, Yorkshire	C. B. Fox	...	...	...	...	...	...	...
Newcastle, Northumberland	W. Lyall	·699	...	...	...	...	...	...
Wylam Hall, Northumberland	G. C. Atkinson	...	...	...	...	...	...	...
North Shields, Northumberland	Rev. R. F. Wheeler.	...	...	...	...	...	...	...
Cockermouth, Cumberland	H. Dodgson	·591	...	...	...	...	...	...
Carmarthen	G. J. Hearder	·495	...	...	·485	...	...	...
Llandudno, Denbighshire	J. Nicol	·640	...	...	...	...	...	...
Pwllheli, Carnarvonshire	W. Jones	...	...	...	...	...	...	...
Haverfordwest, Pembrokeshire	E. P. Phillips	...	...	...	...	...	...	...
Guernsey		...	...	...	...	...	·400	...
Culloden, Invernesshire	A. Forbes	·720	·697	·671	·661	...	...	...
Eyemouth, Berwickshire	Communicated by A. Buchan.	·732	...	...	...	...	...	...
East Linton, Haddingtonshire		...	...	...	...	...	...	...
Smeaton, Haddingtonshire		·624	...	...	...	...	...	...
Dalkeith, Edinburghshire		...	...	...	...	...	...	...

Note.—The readings given in Roman

January 23rd, 9 P.M., to January 24th, 9 P.M. (reduced to sea-level).

	January 24th.																
	5.	6.	7.	8.	9.	10.	11.	noon.	1.	2.	3.	4.	5.	6.	7.	8.	9.
+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+
60	...	...	...	...	·770	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·717	...	...	...	...	...	·787	...	...	...	...	...	...
	...	...	...	...	·667	...	...	...	...	...	·678	...	...	...	...	...	...
	...	...	...	...	·709	...	...	...	...	...	·707	...	...	...	...	...	...
	...	...	...	·708	...	...	...	...	...	·766	...	·764	...	·764	...	...	...
	...	...	...	...	·727	...	...	...	...	...	·764	...	...	...	...	...	·724
	·403	...	...	...	·643	...	...	...	...	...	...	...	...	...	...	...	·795
	...	...	...	...	·662	...	...	...	...	...	...	...	...	...	...	...	...
0	·33	...	...	...	·65	...	...	...	...	...	...	...	...	...	...	·800	...
20	...	...	...	·540	·590	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·509	...	...	...	...	...	...	...	...	...	...	...	·666
8	·19	·21	·38	·49	·59	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	·35	...	·48	...	...	...	...	...	...	...	...	...	...	...	...
	...	·248	...	...	·504	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·543	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·332	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·476	...	...	...	...	...	·696	...	...	...	...	...	...
	...	...	...	...	·339	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·253	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·30	·27	·37	·51	·57	·62	·67	...	...	...	...	...	...
	...	...	...	·489	...	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·463	...	...	...	...	...	...	...	...	...	...	...	·726
	...	...	...	·402	...	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	·427	...	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	·483	...	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·283	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	·495	...	...	...	·724	...	...	...
	...	...	...	...	·360	...	...	...	...	...	·553	...	...	...	...	...	·796
	...	...	...	·399	...	...	...	·355	...	...	...	...	...	...	...	...	...
	...	...	...	·528	...	...	...	...	...	·505	...	...	...	·716	...	...	...
	...	...	...	...	·506	...	...	...	...	...	...	...	...	...	...	...	·663
	...	...	...	...	·625	...	...	...	...	...	·615	...	...	...	...	...	·605
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	·660
	...	...	...	...	·552	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	·641	...	...	...	...	...	·643	...	...	...	...	...	·703
	...	...	...	...	·847	...	...	...	...	...	...	...	...	...	...	...	...
	...	·524	·536	...	·593	...	...	...	...	...	...	...	...	·566	...	...	...
	...	...	...	...	·545	...	...	...	...	...	...	...	...	...	...	...	·714
	...	...	...	...	·570	...	...	·440	...	...	...	...	...	...	...	...	...
	...	...	...	...	·544	...	...	...	...	...	...	...	...	...	...	...	·621
	...	...	...	...	·578	...	...	...	...	...	...	...	...	·575	...	...	...

...e have been interpolated.

TABLE I. (*continued*). Readings of the Barometer at each hour, from

Stations.	Observer.	January 23rd.			January 24th.			
		9.	10.	11.	Mid-night	1.	2.	3.
		in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+	in. 28+
Leith, Edinburghshire	Communicated by A. Buchan.	...	...	...	...	...	...	...
Dundee, Forfarshire............		·703	...	...	...	...	...	...
Arbroath, Forfarshire		...	...	...	...	...	...	...
Eallabus, Islay		·576	...	...	...	...	...	...
Stornoway, Hebrides		·680	...	...	...	...	...	...
Sandwick, Orkney		·900	...	...	...	...	...	...
		29+						
North Unst, Shetland		·146	...	...	...	...	...	...
Thorshavn, Farö		·104	...	...	...	...	...	...
Stykkisholm, Iceland		·455	...	...	...	...	...	...

about 40 miles per hour. At Breinton, Hereford, the Rev. W. Clement Ley observed 28·42 in., "which," he says, "I believe was *nearly* the minimum; but" the barometer "had commenced or was commencing to rise. The wind at that time had *backed* through S.E. to N.E., and was blowing strongly with rain (showing the actual minimum to have passed to the S. and E. of this place)."

At 4.30 A.M. 28·18 in. was observed at Bristol from an aneroid.

At 5 A.M. (fig. 6) the centre of the depression was over the S.E. part of Gloucestershire. The lowest reading at this hour was 28·19 in. at Evesham. At Birmingham the barometer was 28·31 in.; at Ross 28·33 in.; at Kew 28·34 in., wind S.S.W., with a velocity of over 50 miles per hour; at Stonyhurst 28·49 in., wind N.N.E., velocity about 8 miles per hour; and at Falmouth 28·63 in., wind W., 23 miles per hour.

By 6 A.M. (fig. 7, p. 199) the depression had passed to the north of Evesham, where the reading of the barometer was 28·21 in. Mr. Burlingham records "at greatest depression steady rain and gusty wind from S.S.W., shifting to W.N.W. at barometer rising; but the wind could not be called fresh at any time." At Wolverhampton the barometer was 28·25 in.; at Birmingham 28·27 in.; at Kew 28·37 in., wind S.S.W., velocity 50 miles per hour; and at Stonyhurst 28·46 in., wind N.N.E., velocity about 10 miles per hour.

By 7 A.M. (fig. 8) the depression appears to have travelled past Birmingham and to have arrived near Derby. Unfortunately the number of records is insufficient to show where the centre of the depression actually lay at this time. The readings for this hour were:—at Birmingham 28·31 in.; at Evesham and Halifax 28·38 in.; at Stonyhurst 28·44 in., wind N., velocity 15 miles per hour; and at Kew 28·47 in., wind S.W., velocity 45 miles per hour.

For 8 A.M. records are more numerous, especially along the coast; but there are none where most required, viz. in Lincolnshire, Derbyshire, and Leicestershire; this is very unfortunate, as it is impossible, for this reason, to determine where the centre of the depression fell. The lowest reading (of those that were received) was at Scarborough, viz. 28·28 in., wind E., force 6. It was also lower at Halifax at this than at any other hour, being only 28·35 in. At Birmingham it was 28·41 in.; at

January 23rd, 9 P.M., to January 24th, 9 P.M. (reduced to sea-level).

January 24th.																	
4.	5.	6.	7.	8.	9.	10.	11.	noon.	1.	2.	3.	4.	5.	6.	7.	8.	9.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+	28+
..	...	...	...	...	·584	...	...	...	...	...	...	...	...	..	...	...	·680
..	...	...	...	...	·600	...	...	...	...	...	...	...	...	...	...	...	·633
..	...	...	...	...	·580	...	...	...	...	...	...	·500	...	...	...	...	·595
..	...	...	...	...	·550	...	...	...	...	...	...	...	...	...	...	...	·626
..	...	...	...	...	·478	...	...	...	...	...	...	...	...	...	...	...	·573
..	...	...	...	...	·692	...	...	...	...	...	...	...	...	...	...	...	·592
..	...	...	...	...	·906	...	...	...	...	...	...	...	·622	...	...	...	·716
..	...	...	...	...	·988	...	...	...	...	...	...	...	...	...	...	...	·935
					29+			29+									29+
..	...	...	...	...	·460	...	...	·472	...	...	...	...	...	...	...	...	·471

Stonyhurst 28·43 in., wind N.W., velocity 18 miles per hour; and at Yarmouth 28·43 in., wind S.S.W., force 9.

At 9 A.M. (fig. 10) the depression appears to have been over the river Trent, and near to Lincoln. The lowest reading of the barometer at this hour was 28·25 in., at Appleby, near Brigg. At Beverley it was 28·28 in.; at Killingholme 28·30 in.; at Nottingham 28·33 in.; at Ripley 28·34 in., wind W.; at Halifax and Wisbeach 28·37 in.; and at Stonyhurst 28·44 in., wind W.N.W., with a velocity of 20 miles per hour.

At 9.40 A.M. the minimum pressure passed Killingholme, near Ulceby, Lincolnshire, when 28·25 in. was observed: this is also borne out by wind-observations at Faldingworth, near Market Rasen, where at 9 A.M. the wind was from the S.S.E., fresh only; but at 9.45 A.M. it had veered to W., and was blowing a hurricane.

From this time the depression seems to have passed from the land to the sea, but to have kept along the east coast for some distance, going N., and then to have passed out over to the North Sea. The last trace of it was observed at Aberdeen at 4.30 P.M., where the minimum reading recorded by the barograph was 28·444 in., the wind at that time being N.

It will be obvious from the foregoing remarks that the self-recording barographs at Falmouth, Kew, Birmingham, Halifax, Stonyhurst, and Aberdeen have been of considerable service in the inquiry. At an early stage the barograph at Bidston Observatory gave readings discordantly high. The cause of this discrepancy has not yet been discovered; but several different modes of investigation have led to the uniform deduction of an error in excess, varying in amount from 0·03 in. to 0·08 in. Comparisons with the readings at the adjacent station of Hinderton, and also with the nearest station quoted in the Daily Weather Report (Holyhead), are given in Appendix II. The error was probably one of shifted zero-point, the *changes* having been accurately recorded; a subtractive correction of 0·05 in. has consequently been applied to all the readings from that station used in this paper, to enable the records from so valuable a station to be turned to some account.

Table II. gives the lowest reading of the barometer at the several stations, with the time at which it was recorded, and also notes whether the record was the absolute minimum, or only the lowest observed reading.

Fig. 1.

Fig. 2.

Fig. 3.

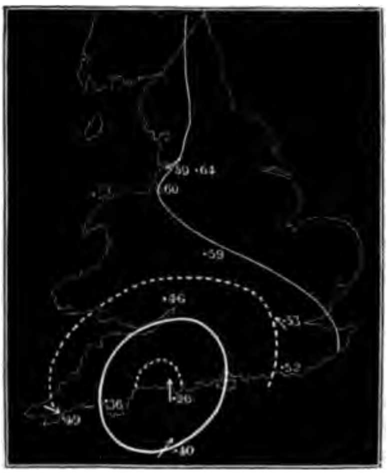


Fig. 4.

Fig. 5.

Fig. 6.

II. Lowest observed reading of the Barometer on January 24th, 1872 (reduced to sea-level).

Stations.	Time.	Reading.	Minima.
		in.	
th	0.0 A.M.	28·424	True minimum.
th	0.0 „	28·489	Lowest observed.
th	1.0 „	28·319	True minimum.
n	1.0 „	28·518	Lowest observed.
....	1.30 „	28·455	„ „
y	2.0 „	28·400	True minimum.
....	2.40 „	28·208	Lowest observed.
eld Turgiss	2.45 „	28·466	„ „
urst	2.55 „	28·456	„ „
ng	3.0 „	28·432	„ „
npstead..................	3.0 „	28·433	„ „
....	3.45 „	28·322	„ „
on	4.0 „	28·46	„ „
Salisbury	4.0 „	28·293	„ „
ton........................	4.0 „	28·345	„ „
....	4.0 „	28·391	„ „
lge Wells	4.0 „	28·502	True minimum.
....	4.0 „	28·336	„ „
n	4.0 „	28·42	Lowest observed.
Hill	4.10 „	28·38	„ „
Bristol	4.30 „	28·18	„ „
Square.................	4.47 „	28·332	True minimum.
am	4.55 „	28·395	„ „
....	5.0 „	28·403	Lowest observed.
n	5.20 „	28·179	„ „
ich........................	5.20 „	28·38	True minimum.
gham	6.0 „	28·272	„ „
hampton	6.0 „	28·248	Lowest observed.
Tooting..................	6.0 „	28·380	„ „
....	7.0 „	28·35	„ „
....	7.0 „	28·50	„ „
....	7.50 „	28·38	True minimum.
ton	8.0 „	28·489	Lowest observed.
afford.....................	8.0 „	28·402	„ „
....	8.0 „	28·353	True minimum.
urst........................	8.0 „	28·425	„ „
Walden..................	8.0 „	28·398	Lowest observed.
ith	8.0 „	28·430	„ „
ough	8.30 „	28·283	„ „
ch	9.0 „	28·398	„ „
h..........................	9.0 „	28·397	„ „
ham	9.0 „	28·332	„ „
....	9.0 „	28·339	„ „
y...........................	9.0 „	28·283	„ „
y, Brigg	9.0 „	28·253	„ „
holme.....................	9.40 „	28·25	True minimum.
Hall	Noon.	28·355	Lowest observed.
nton	Noon.	28·440	„ „
h	4.0 P.M.	28·500	„ „
en	4.30 „	28·444	True minimum.
n	6.0 „	28·524	Lowest observed.

i the foregoing data the depression appears to have touched the f England near Falmouth about midnight, and to have passed along st to Upwey which was reached a little before 3 A.M., thus travelling rate of about 37 miles an hour. It then took a northerly course sed over Wiltshire, Gloucestershire, Worcestershire, and Warwick-eaching Birmingham by 6 A.M., the rate of progress from 3 to

6 A.M. having been about 40 miles an hour. From this time the centre of depression took a north-north-easterly course, passing over Derbyshire and Nottinghamshire, and had reached the N.W. part of Lincolnshire by 9 A.M., thus having travelled at the rate of about 30 miles an hour. This seems to show that the coast-line caused it to move slowly from Falmouth to Upwey, and that it travelled *across England* at a faster rate till it reached Lincolnshire and Yorkshire, where it was delayed, probably being retarded by the Wold hills, and then passed out of the Humber between 10 and 11 A.M. The evidence, however, is insufficient to prove whether this was actually the case or whether the depression merely passed over England in a N.E. by N. direction, as shown by the arrow (fig. 11), at a uniform rate of about 30 miles an hour.

A noticeable feature is that the force of the wind on the eastern and south-eastern side of the depression was much stronger than on the western; this is no doubt owing to the gradients on the western side having been much steeper than on the eastern, so as to cause an inrush of air into the region of lower pressure.

The gale was one of the most violent that had been experienced for a considerable period; many lives were lost, and much damage was done to property and shipping.

It may perhaps be interesting to some to know that the "pocky-" kind of cloud was observed previous to this depression. Mr. Glyde, of Forest Hill, writes as follows:—"On the 23rd, at 2.15 to [illegible] P.M. the under surface of heavy and dark cumulo-stratus cloud in the [illegible] presented a singular appearance, being convex or bulbous in several portions lying in close contiguity—the under surface being hard, clearly defined and hanging in festoons, as if supporting heavy circular substances internal to them."

In order to get analogous instances of depressions in the vicinity of the Metropolis it is necessary to go back for a considerable period. There are only four on record in which this depression has been exceeded, viz. in 1791, 1814, 1821, and 1843. On January 20th, 1791, 28·10 in. was observed at Sion House, in Middlesex, which, corrected and reduced to sea-level, would be about 28·15 in.; and at Paternoster Row, on the same day, 28·20 in. (28·28 in. at sea-level) was observed.

On January 29th, 1814, at 5 P.M., Mr. Belville's observations give 28·233 in.; and he says, "this depression happened at the close of the great frost, when the river Thames was frozen over, and was preceded by a stormy wind from S.S.E. with much rain." Luke Howard states, "the *minimum* of pressure, 28·32 in., occurred about 6 P.M. It was not confined to a small space of time. As the barometer began to rise the wind came round by S.W. to N.W., and blew with great violence till near morning."

In the extreme depression of 1821*, which occurred on Christmas day, the pressure, as deduced from Luke Howard's observations at Tottenham, was at 5 A.M. 27·93 in., and at the Royal Observatory, Greenwich,

* *Vide* Dove, 'Law of Storms,' p. 162.

Fig. 7.

Fig. 8.

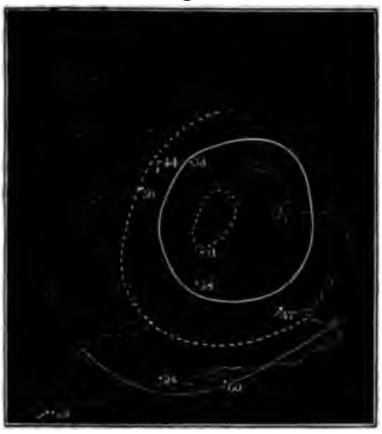


Fig. 9.

Fig. 10.

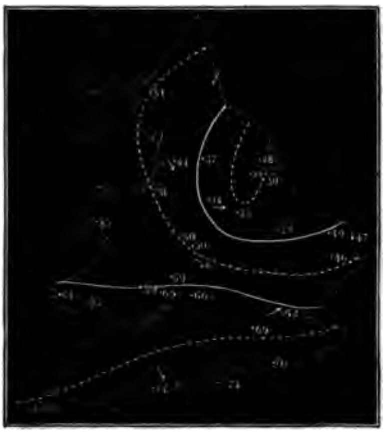
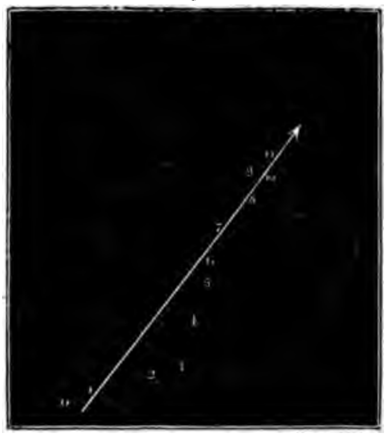


Fig. 11.



28·01 in. at the same hour. At 6 A.M. Mr. Squire's observations at Epping gave 28·10 in., and those at Sion House 28·25 in. at 8 A.M.

The depression of January 13th, 1843, was more accurately observed. The minimum of 28·266 in. at the Royal Observatory, Greenwich, occurred at 0.53 P.M.; at Cambridge at 1.35 P.M. it was 28·220 in., and at Norwich 28·205 at 2 P.M.

Table III. gives the minimum reading of the barometer at Greenwich in each year for sixty-two years, from 1811 to 1872: those from 1811 to 1840 are from the Journals of the late Mr. Henry Belville, at present in the author's possession; and those from 1841 to 1872 at the Royal Observatory, taken from the 'Greenwich Observations.'

TABLE III. Lowest reading of the Barometer at Greenwich during sixty-two years, 1811–1872 (reduced to sea-level).

From Mr. Belville's Journals.				From the 'Greenwich Observations.'			
Year.	Date.	Hour.	Reading.	Year.	Date.	Hour.	Reading.
			in.				in.
1811...	Oct. 26.	Noon.	28·711	1841...	Oct. 6.	10.57 A.M.	28·867
1812...	Oct. 19.	6 P.M.	28·542	1842...	Oct. 23.	11.40 A.M.	28·851
1813...	Oct. 17.	8 A.M.	28·687	1843...	Jan. 13.	0.53 P.M.	28·266
1814...	Jan. 29.	5 P.M.	28·233	1844...	Feb. 26.	2.0 P.M.	28·695
1815...	Apr. 22.	Noon.	28·859	1845...	Dec. 20.	6.0 A.M.	28·829
1816...	Dec. 12.	Evening.	28·748	1846...	Dec. 23.	8.0 A.M.	28·706
1817...	Dec. 8.	....	28·532	1847...	Dec. 7.	2.30 A.M.	28·550
1818...	Mar. 4.	Night.	28·530	1848...	Feb. 26.	9.45 A.M.	28·469
1819...	Feb. 21.	Noon.	29·156	1849...	Jan. 10.	Noon.	28·999
1820...	Oct.	....	28·699	1850...	Nov. 20.	Noon.	28·762
1821...	Dec. 25.	5 A.M.	28·016	1851...	Mar. 23.	10.30 A.M.	29·009
1822...	Dec. 2.	....	29·033	1852...	Oct. 27.	9.0 A.M.	28·913
1823...	Feb. 2.	....	28·613	1853...	Oct. 19.	3.0 P.M.	29·001
1824...	Nov. 23.	....	28·484	1854...	Jan. 7.	9.0 P.M.	28·979
1825...	Nov. 10.	Noon.	28·755	1855...	Mar. 22.	Noon.	28·926
1826...	Nov. 13.	10 P.M.	28·806	1856...	Sept. 28.	10.50 A.M.	28·858
1827...	Mar. 4.	Noon.	28·800	1857...	Oct. 8.	3.0 P.M.	28·839
1828...	Feb. 22.	Morning.	28·954	1858...	Nov. 27.	3.0 P.M.	29·014
1829...	Apr. 14.	10 P.M.	28·964	1859...	Dec. 26.	6.38 A.M.	28·660
1830...	Jan. 20.	8 A.M.	28·736	1860...	Jan. 24.	1.50 P.M.	28·725
1831...	Dec. 7.	Noon.	28·980	1861...	Nov. 13.	9.30 P.M.	28·960
1832...	Aug. 28.	2 P.M.	29·152	1862...	Oct. 19.	9.0 P.M.	29·128
1833...	Nov. 28.	7 P.M.	28·755	1863...	Nov. 2.	9.0 A.M.	28·938
1834...	Jan. 12.	3 P.M.	29·111	1864...	Nov. 14.	2.20 P.M.	28·776
1835...	Oct. 10.	Morning.	28·747	1865...	Jan. 14.	11.55 A.M.	28·560
1836...	Feb. 2.	8 P.M.	28·691	1866...	Feb. 11.	4.34 P.M.	28·620
1837...	Nov. 1.	4 P.M.	28·799	1867...	Jan. 8.	7.21 A.M.	28·705
1838...	Nov. 28.	10 P.M.	28·653	1868...	Dec. 24.	2.10 P.M.	28·690
1839...	Jan. 30.	10 P.M.	29·015	1869...	Sept. 12.	5.30 A.M.	28·750
1840...	Feb. 4.	Noon.	28·627	1870...	Oct. 24.	7.0 A.M.	28·895
				1871...	Jan. 16.	7.20 A.M.	28·879
				1872...	Jan. 24.	5.20 A.M.	28·380

In conclusion the author has to express his thanks to Mr. Symons for the valuable assistance he has given him in drawing up this paper; to the Meteorological Office for the use of observations; and to Mr. Buchan for the Scottish observations.

APPENDIX I.

Observations of the Barometer taken during the Depression of January 23–24 (reduced to sea-level).

Plymouth, Devon. J. Merrifield, Observer.

Time.	Reading of Barometer.	Wind.		Weather.
		Direction.	Force (0—12).	
	in.			
January 23, 11.0 P.M.	28·537	W.S.W.	3	r. r.
„ 23, 11.15 „	28·487	„	3	r. r.
„ 23, 11.50 „	28·433	„	3	r. r.
„ 24, 0.5 A.M.	28·405	„	3	......
„ 24, 0.25 „	28·373	„	3	r. r.
„ 24, 0.40 „	28·349	„	4	r. r.
„ 24, 1.0 „	28·319	„	3	r. r.
„ 24, 1.15 „	28·321	„	2	......
„ 24, 1.30 „	28·332	„	5	r. r.
„ 24, 1.45 „	28·344	„	3	r. r.

Upwey, Dorchester, Dorset. J. Miller, Observer.

Time.	Reading of Barometer.	Temp. on Thermometer-stand.	Remarks.
	in.	o	
January 23, 11 45 P.M....	28·519	......	S.E. moderate, and heavy rain.
„ 24, 0.15 A.M....	28·467	......	
„ 24, 0.45 „ ...	28·401	46·3	
„ 24, 1.20 „ ...	28·327	......	S. rising.
„ 24, 2.20 „ ...	28·234	......	S. increasing; rain ceased.
„ 24, 2.40 „ ...	28·208	......	
„ 24, 3.15 „ ...	28·219	......	S.W., a furious gale (which moderated between 5 and 6 A.M).
„ 24, 3.30 „ ...	28·264	......	
„ 24, 7.15 „ ...	28·559	......	
„ 24, 9.0 „ ...	28·738	47·0	N.W. strong.
„ 24, 11.30 „ ...	28·792	......	S.W. strong.

Camden Square, London. G. J. Symons, Observer.

Time.	Reading of Barometer.	Time.	Reading of Barometer.
	in.		in.
January 23, 9.0 P.M.........	28·848	January 24, 1.0 A.M.	28·645
„ 23, 11.15 „	28·785	„ 24, 1.15 „	28·618
„ 23, 11.30 „	28·775	„ 24, 1.30 „	28·593
„ 23, 11.45 „	28·743	„ 24, 1.45 „	28·574
„ 24, 0.0 A.M.........	28·730	„ 24, 2.0 „	28·541
„ 24, 0.15 „	28·716	„ 24, 2.15 „	28·506
„ 24, 0.30 „	28·695	„ 24, 2.30 „	28·482
„ 24, 0.45 „	28·675	„ 24, 2.45 „	28·455

Camden Square, London. G. J. Symons, Observer (*continued*).

Time.	Reading of Barometer.	Time.	Reading of Barometer.
	in.		in.
January 24, 3.0 A.M.	28·432	January 24, 5.0 A.M.	28·345
" 24, 3.15 "	28·414	" 24, 5.15 "	28·348
" 24, 3.30 "	28·391	" 24, 5.30 "	28·350
" 24, 3.45 "	28·382	" 24, 5.45 "	28·355
" 24, 4.0 "	28·365	" 24, 6.0 "	28·360
" 24, 4.15 "	28·354	" 24, 6.15 "	28·372
" 24, 4.30 "	28·344	" 24, 6.30 "	28·386
" 25, 4.45 "	28·338	" 24, 6.45 "	28·414
" 24, 4.47 "	28·332	" 24, 7.0 "	28·420

Ross, Hereford. H. Southall, Observer.

Time.	Reading of Barometer.
	in.
January 24, 0.10 A.M.	28·622
" 24, 1.8 "	28·529
" 24, 3.45 "	28·322
" 24, 5.5 "	28·335
" 24, 9.5 "	28·651
" 24, 9.45 "	28·681
" 24, 2.55 P.M.	28·773

Evesham, Worcester. R. Burlingham, Observer.

Time.	Reading of Barometer.
	in.
January 24, 2.30 A.M.	28·443
" 24, 3.0 "	28·376
" 24, 4.20 "	28·230
" 24, 4.35 "	28·216
" 24, 4.50 "	28·196
" 24, 5.5 "	28·185
" 24, 5.20 "	28·179
" 24, Absent ¾ hour	
" 24, 6.5 A.M.	28·223
" 24, 6.20 "	28·263
" 24, 6.35 "	28·307
" 24, 6.50 "	28·347
" 24, 7.5 "	28·386
" 24, 7.20 "	28·418
" 34, 7.35 "	28·449
" 24, 8.35 "	28·540

Killingholme, Ulceby, Lincolnshire. Rev. J. Byron, Observer.

Time.	Reading of Barometer.
	in.
January 24, 8.30 A.M.	28·32
„ 24, 9.40 „	28·25
„ 24, 10.15 „	28·28
„ 24, 10.30 „	28·31
„ 24, 11.0 „	28·37
„ 24, Noon	28·51
„ 24, 1.0 P.M.	28·57
„ 24, 2.40 „	28·66

APPENDIX II.

Comparisons of the Barometric Readings at Bidston with those at Hinderton and Holyhead.

Date.	Hinderton.	Bidston.	Diff.	Date.	Holyhead.	Bidston.	Diff.
1872.	in.	in.	in.	1872.	in.	in.	in.
Jan. 19, 8 A.M....	29·277	29·31	+0·033	Jan. 19, 8 A.M. ...	29·23	29·31	+0·08
„ 21, 8 „ ...	29·685	29·72	+0·035	„ 21, 8 „ ...	29·68	29·72	+0·04
„ 22, 8 „ ...	29·473	29·59	+0·117	„ 22, 8 „ ...	29·50	29·59	+0·09
„ 23, 8 „ ...	28·836	28·88	+0·044	„ 23, 8 „ ...	28·75	28·88	+0·13
„ 23, 11 P.M....	28·688	28·72	+0·032	„ 23, 2 P.M. ...	28·61	28·66	+0·05
„ 24, 8 A.M....	28·489	28·55	+0·061	„ 24, 8 A.M. ...	28·51	28·55	+0·04
„ 24, 11 P.M....	28·702	28·75	+0·048	„ 24, 2 P.M. ...	28·57	28·66	+0·09
„ 25, 8 A.M...	28·806	28·85	+0·044	„ 25, 8 A.M. ...	28·70	28·85	+0·15
Mean	......	......	+0·052	Mean	......	......	+0·084

The discussion on this paper will be found at p. 220.

XXVI. *Land and Sea Breezes.*

By JOHN KNOX LAUGHTON, M.A., F.R.A.S.

[Received May 19, 1873. Read May 19, 1873.]

THE subject of this paper is one which meteorologists in general have, perhaps, rather neglected, having given what Paley has called an "otiose assent" to the plausible theory of differences of temperature; and, content with that, have inquired very little into the peculiarities of the phenomena known as land and sea breezes. And yet these peculiarities are worth examination, and on examination lead very decidedly to the conclusion that our otiose assent has been a mistake, and that, whatever may be the cause of land and sea breezes, the changing temperatures of land and sea have, in the manner ordinarily understood, very little, if any thing at all, to do with them. The evidence of this divides itself into two classes (geographical and physical), which I will, in the first place, consider separately.

If land and sea breezes are caused by the difference of temperature

over land and sea, as stated in the usually received explanation, it is quite clear that they must be most strongly marked on coast-lines, where the differences of temperature are most strongly marked; also that since the differences at sea are, in the same parts of the world, pretty nearly constant, they must depend almost entirely on the differences on land, and therefore must be strongest and most marked where the land, being of the nature of an arid desert, is subject to the greatest extremes of heating by day and chilling by night. But this conclusion, the necessary corollary of the ordinary theory, is distinctly *false*. So far as I know, after a long inquiry, there is no place in the whole world where the country near the coast is of this arid desert nature, and the sea or land breezes blow strongly. All up the Red Sea, for instance, there is plenty of sandy desert on both sides; but the sea and land breezes are everywhere faint. At Jaffa, on the coast of Syria, there is a bare sandy plain stretching inland for many miles; as before, the breezes are very faint; whilst they blow freshly at Beyrout, some miles to the northward along the same coast, where the country is well cultivated and green with mulberry-plantations. Along the south coast of Arabia, in the Gulf of Persia, on the north-west and south-west coast of Africa are numerous wide districts where desert is the rule, where sea and land breezes are almost unknown; on the other hand, wherever the breezes do blow strongly, and form an important consideration in the navigation of the coast or in social life, the country is green, overgrown, rank with verdure, or, at any rate, well cultivated. I have just spoken of Beyrout; there, and at the lovely Palermo, the breezes blow more strongly than anywhere out of the tropics; whilst within the tropics, of all known places, they blow most strongly at Port Royal; but strongly also at many of the West-India Islands, parts of the coast of Central America, some of the islands of the Eastern Archipelago, on the north coast of Java, in the Straits of Malacca, and other similar places, where, as I have said, rank vegetation is the rule.

The evidence of this in its details is much too bulky to lay before you; so much of it as is printed may be found readily enough, scattered through the numerous volumes of the Sailing-Directions published by the Admiralty; in addition to which I have my own personal experience, and the experience of scores of friends whom I have questioned on the subject.

Now I do not here put forward any suggestion that rank vegetation increases the force of the land and sea breezes; but I wish to put forward, as prominently as I can, the statement of fact that these breezes are not found to blow strongly where differences of temperature are extreme, and are found to blow strongly where the differences of temperature are moderate or even trifling; and from it I draw the conclusion that these differences of temperature are not the cause of the sea and land breezes.

This is, in outline, the geographical evidence, and the conclusion which results from it; the physical evidence tends in the same direction.

We know that when a fire is lighted and the air is pressed in towards it, the motion is imparted first to the air immediately near the fire, then to that which is more remote, the circle of motion gradually ex-

sending from the centre outwards. If a sea breeze is caused by the heating up of the land, it must spring up in the same way, be first felt close to the shore, and gradually extend itself backwards. But, as a matter of fact, this is not the case; it is first felt out at sea and comes gradually in; looking from the shore, we can see it advancing, a long line on the smooth water in-shore of it—a "fine black curle upon the water," as Dampier has described it: it advances slowly, so that it can be seen perhaps for an hour before the breeze is felt; but when the breeze does come, it may be, and frequently is, blowing fresh, with a velocity, not of the 5 or 10 miles an hour with which it has come in, but of 30, 40, or even 50 miles an hour.

Now, if the wind were blowing straight on end, pressed in towards some centre of diminished density, it would certainly blow straight past the observer at or near the shore-line with its full velocity: coming in in the way it does seems to speak rather of its being driven in by an increasing force from without, as air might be driven by the bellows; and being so driven in, unable sufficiently to overcome the inertia of the air which it has to drive before it, which is moored (so to speak) by the friction of the land, a great part of it curls upwards and backwards on itself, forming what I would describe as a cyclone with its axis horizontal; so that whilst the wind near the surface is blowing freshly towards the land, higher up it is blowing freshly out to sea. That this is, sometimes at least, really the case, was very satisfactorily proved by the misadventure of an aëronaut at Madras, who attempted to go inland in a balloon with the sea breeze; but, instead, was carried out to sea, and fell into the water a couple of miles beyond the shipping in the roadstead. The case is mentioned by Admiral Smyth, in his Sailor's 'Word-book,' but was brought specially to my notice by Captain Toynbee, who was able to give me more exact details concerning it.

The land breezes, in a similar way, do not begin at sea and creep back towards the land; they very distinctly come off the land. The 'Sailing-Directions' are full of warnings against the first puffs of the land breeze, which, in places, come off like sharp squalls; in many places, too, the smell of the land is the first intimation a ship in the roadstead has of the approach of the land breeze, which very shortly follows in noticeable strength.

Hence, then, I conclude that, with regard both to sea breezes and to land breezes, the cause of the wind is not a decrease of density or pressure in front, but an increase behind—that, in fact, they are winds of *propulsion*, not of *aspiration*.

I am quite well aware that many distinguished meteorologists have laid down as a positive rule that all winds are winds of aspiration, and that there are no such things as winds of propulsion. I believe that the laying down this rule was merely a violent reaction against the theories of past centuries, one of which attributed winds to the exhalations or emanations from the earth, and referred, as one of many proofs of the reality of these, to the well-known "Grotta del cane," near Naples.

Reactions may frequently be useful, but they generally go too far, and err in the opposite direction. The reaction has certainly gone too far here; and though *storms* are almost always accompanied by a depression of the barometer, and may perhaps be considered to be caused by the defect of pressure, still records of very manifest winds of propulsion are sufficiently common, and would be, I believe, even more common, were it not that many meteorologists feel trammelled by the rule I have referred to. At any rate, all the evidence I have collected as to the origin of sea and land breezes, and their mode of advance, leads forcibly to the conclusion that they are winds of propulsion.

Up to this point I believe that I am fully borne out by satisfactory evidence; when, however, we come to inquire what the propelling force which causes these winds is, direct evidence fails us: there have been no satisfactory observations on the subject; I think I may say there have been no observations at all. There seems to me, however, evidence of another kind, derived from the known and from the theoretical conditions of the atmosphere and the changes it is subject to, which points out the line that future inquirers might do well to examine.

And, first, with regard to the sea breeze. We may regard it as established that, as the day advances and the sun gains power, evaporation goes on much more copiously over the sea than over the land; the quantity of vapour in the air over the land is at its minimum in the early morning, and increases as the sea breeze sets in; the marked increase of vapour comes from the sea. This seems to render it probable that the formation of this vapour over the sea, during the morning and forenoon, gives rise to the propelling force; the vapour adds its elastic force to the elastic force of the atmosphere, and the two combined exercise a pressure greater than that of the land air, and drive it back. The commonly received opinion is that any increase given to the elastic force of the air at any place, whether by addition of vapour or increase of temperature, seeks to establish, and does establish, equilibrium with neighbouring pressures by upward expansion alone: this opinion certainly rests on very insufficient foundation; when the elastic force of the lower stratum of a particular column of air is increased it will manifest itself in whatever direction it finds least resistance. I hope on some future occasion to be permitted to bring this subject before you at greater length; but meantime, in the case before us, it seems to me that, since the increased pressure is opposed seaward by a similar increased pressure, and upward by the weight of the atmospheric column, it finds the least resistance towards the land, and forces back the air in that direction. This motion is the sea breeze; and I believe that the reason of its being less strongly marked on the coasts of desert lands is, that the rapidly increasing temperature over the desert during the forenoon acts on the land air in the same way that the rapidly increasing vapour does on the sea air; it increases its elastic force, which thus exercises a pressure outwards sufficient, more or less completely, to balance the pressure inwards. An extreme case of this is mentioned by Mr. Boulton in a recent number of our Journal

(No. 3, p. 97), where he describes the land and sea breezes on the coast between St. Helena Bay and the mouth of the Orange River as being frequently reversed, so that a *hot* land breeze blows by day, and a sea breeze by night. Over dense vegetation there is not a great or rapid increase of temperature, and the increasing pressure from the sea is unopposed. Vegetation thus does not in any way cause, increase, or assist the sea breeze; it merely prevents that resistance to it which a dry burning soil encourages. The real cause of the increased force which we often find in the sea breeze I conceive to be a neighbouring mountain-range in the background. The moist wind from the sea, being pressed up the mountain-slope, precipitates its vapour sometimes as fog or mist, sometimes as deluging rain; in doing this, it necessarily loses immediately a certain part of its elastic force, and permits the air from the sea to press in with augmented strength. This seems to be sufficiently established by the facts that the sea breeze nowhere blows with any great strength except where mountains are in the background, and that these mountains are, during the afternoon, when the sea breeze has got well home to them, constantly enveloped in mist or storm. The Blue Mountains of Jamaica afford the best illustration of this; and it is on the coast of Jamaica, more especially of Port Royal, that the sea breeze has a force unknown anywhere else.

I have already spoken of the way in which an observer on shore, or near the shore, sees the breeze coming in from sea. A very large amount of evidence assures me that it always, or almost always, does so; but, on the other hand, evidence from observers in the offing leads to the conclusion that it also creeps back seawards. This backward extension must be regarded as the continually increasing supply to the continually increasing body of air which is forcing itself in towards the land; and though it seems probable that a large part of this volume is simply rotating on a horizontal axis, and constantly reappearing like the members of a stage procession, a great part is certainly carried inland up the mountain-slopes and into the higher regions of the atmosphere. So long as the sea breeze increases in force so long will it continue to eat its way back; and it will cease to do so as it begins to slacken.

But meantime, during all the later part of the day, the breeze from the sea has been pouring air in against the mountains, which has formed an ascending column of greater or less magnitude. This column, by its inertia, continues to ascend for some time after the force below has ceased to act; so that, when its upward motion stops, it is far above its position of equilibrium; it therefore, reversing its motion, begins to descend, and, gathering way as it does so, it comes down the mountain-slope with continually increasing velocity, and is deflected seaward as the land breeze. That such an uplifted column may, in a similar manner, descend and be deflected out to sea, when there are no mountains in the background, is dynamically possible enough; but, as a matter of geographical fact, the land breeze has nowhere any noticeable strength unless there are mountains in the immediate neighbourhood.

The account which I have given of the phenomena of land and sea breezes is meagre enough; exact observations referring to them have nowhere been taken; and, indeed, it may be doubted whether, with an instrument like the barometer, sluggish at its best, which shows a gradient of ·06 of an inch in 50 miles for an approaching gale of wind, we shall be able to detect the differences of elastic force, within a distance of 20 miles, that possibly give rise to a pleasant breeze of 3 or 4 on the Beaufort scale. Still inquiry and observation ought to do something, and must lead to more extended knowledge. I think that the theory which I have suggested is based on rational grounds, and is in accordance with the facts, so far as we know them: I shall be pleased to find it more fully confirmed; but I shall be equally well pleased to find it satisfactorily disproved. What I have principally wished has been to combat that otiose assent which has been given to a theory that is, I am persuaded, altogether incorrect. Right or wrong, an otiose assent is unworthy of men of science: it is, perhaps, an *otium*; it is certainly not *cum dignitate*.

The discussion on this paper will be found at p. 236.

XXVII. *Land and Sea Breezes.*

By the Rev. Fenwick W. Stow, M.A., F.M.S.

[Received May 21, 1873. Read May 21, 1873.]

Before I went to live on the north-east coast of Yorkshire in the spring of 1869, I had been accustomed to think of land and sea breezes as a phenomenon peculiar to tropical islands. Very soon, however, my attention was arrested by the extraordinary manner in which the wind shifted in the afternoon. In order to investigate the subject more fully, I contrived, at the beginning of 1870, a rude but accurate apparatus to record continuously the wind's direction. From the records of this instrument the direction of the wind for each hour was deduced, the time of any sudden change being noted, and duplicate copies of these results were sent to the Meteorological Office. The oscillation of the vane was found capable of supplying, when certain corrections depending chiefly upon direction were applied, figures nearly equivalent to the force as estimated upon Beaufort's scale whenever it exceeded 1.

From these results, and from observations taken for me by W. Woodruff, one of the lightkeepers at the North Lighthouse, the subjoined Table has been compiled. A glance will show that in fine settled weather the wind generally shifts about noon to a point between E. and S.E., and not unfrequently shifts again at night to the westward. I felt at first some difficulty in recognizing this phenomenon as essentially the same as that of the land and sea breezes of tropical islands, because I had been led to believe that in that case the breezes blow direct from sea by day and from land by night, whereas at Hawsker the sea breezes blew nearly along the coast. But upon reflection I became convinced that this direction was, in

fact, a clear proof of their origin. When the sun heats the land in spring and summer considerably above the temperature of the sea, it is reasonable to suppose that it diminishes the barometrical pressure over the land compared with that which exists over the colder sea. If, then, we suppose the weather to be otherwise absolutely calm, and no barometrical gradient belonging to the greater movements of the atmosphere to subsist, it seems probable that the gradient due to this unequal heating of land and sea will be steepest at the coast, and the isobars will run along the coast-line. Therefore, according to Buys Ballot's law, a breeze may be expected to blow *along the coast* from right to left as you look out to sea; and this breeze will be strongest at the coast-line, gradually diminishing as you go inland or out to sea. Now from Whitby lighthouses the coast runs in a W.N.W. direction to the mouth of the Tees, and S.S.E. towards Scarborough. My house at Hawsker was 1½ mile S. of the lighthouses, and 1 mile from the sea in a direct line to the N.E. Evidently on such a coast the direction which the sea breeze might be expected to take, if not in any way interfered with, would be from the S.E.; and the actual wind, blowing along the resultant determined by the direction and force of the general current combined with those of the local sea breeze, might be expected to be somewhat uncertain both in direction and force, but to manifest on the whole a decided tendency to blow from the S.E. Now this is exactly what is found to be the case. If, indeed, the pre-existing wind is N.W. or N. it often happens that the wind does not veer to S.E. Sometimes the N.W. breeze dies away in the afternoon, sometimes it veers slightly to the eastward and freshens. This is only what might be expected when we remember that the pre-existing gradients are exactly opposite to those which the diurnal heat would generate, and, further, that with those winds the air over the land is always cool, and in the neighbourhood of Whitby, where they blow from the sea, often extremely cold even in the height of summer. On the contrary, if the wind at 6 A.M. be S. or S.W. it usually *backs*, and if W. or W.S.W. *veers* through N. to E. or E.S.E., from which quarter it often blows with a force of 3, 4, or even 5 on Beaufort's scale*. The days which I have selected in this Table were bright sunny days, without rain, on which the force of the wind was less than 6, occurring during settled weather. There were many more such in 1870 than in 1871; but in August of the latter year a period of hot weather brought a remarkably regular succession of land and sea breezes.

It will be seen that in 1870 a true sea breeze appeared on 37 out of 69 fine days, or, excluding the cold month of August with its N.W. and northerly winds, on 35 out of 57 days; but the land breeze only on 13 nights. In 1871 sea breezes blew from E. or S.E. on 19 out of 25 fine days, and land breezes on perhaps 14. The presence of sea breezes is further shown by the depression of temperature at 3 P.M., coupled with an increase in humidity, the temperature in some months having been actually lower on the selected fine days than at 9 A.M.

* On the whole in 1870 it veered 26 times and backed 19 times towards E.S.E.; in 1871 it veered 11 times and backed 12.

TABLE I. Abstract from

April.

At Hawsker, 340 feet above the sea, 1 mile from sea.

1870.	Wind at 6 A.M. Direction.	Force (0–12).	Direction from which sea breeze blew.	Force (0–12).	Wind at midnight. Direction.	Force (0–12).	Time at which Wind changed: Towards E.S.E.	Time at which Wind changed: Away from E.S.E.	Whether it veered (V) or backed (B) towards E.S.E.
1...	S.S.W.	2	S.E. by S.	3	S.E. by S.	2	2.30 P.M.	Calm.	B.
2...	S.E. by S.	2	(N.E. by N.)	3	N.E. by N.	0	2.30 ,,	Calm.	V.
3...	N.E. by N.	0	E.	3	S.E.	3	1.30 ,,	7.45 P.M.	V.
4...	S.S.W.	4	E.	4	S. by W.	3	2.5 ,,	6.15 ,,	B.
5...	S.S.W.	3	E.S.E.	2	S.	0	3.45 ,,	7.0 ,,	B.
6...	S.	0	...	2	S.	2	...	...	...
7...	S.W. by W.	2	E.	4	S.S.W.	2	0.15 ,,	1.15 ,,	V.
14...	W.	5	E.	4	S.	2	2.45 ,,	9.45 ,,	V.
15...	W. by N.	2	(N.)	2	N.	0	Noon.	Calm.	V.
16...	N.	0	E.S.E.	2	E.S.E.	0	1.30 ,,	4.30 ,,	V.
17...	E.S.E.	0	S.E.	3	S.	3	0.45 ,,	9.0 ,,	V.
18...	S.	2	S.E. by E.	3	S.E.	2	1.40 ,,	3.30 ,,	B.
19...	S.E.	0	(S.)	2	S.	2	Noon.	3.30 ,,	...
20...	S.S.E.	2	E. by S.	3	S.S.E.	2	11 A.M.	4.30 ,,	B.

May.

1870.	Wind at 6 A.M. Direction.	Force (0–12).	Direction from which sea breeze blew.	Force (0–12).	Wind at midnight. Direction.	Force (0–12).	Towards E.S.E.	Away from E.S.E.	Whether it veered (V) or backed (B) towards E.S.E.
5...	N.W.	3	(N.N.W.)	2	N.N.W.	0	...	...	...
6...	N.N.W.	2	(N.N.W.)	3	N.N.W.	0	...	...	...
7...	N.N.W.	2	(N.E. by E.)	2	N.E.	0	4 P.M.	...	V.
8...	N.E.	2	E.	3	S.	2	7 A.M.	9.0 P.M.	V.
9...	S.	0	E.N.E.	4	S.E. by S.	2	11 A.M.	8.0 ,,	B.
21...	W.S.W.	0	E.	2	S.W.	2	11.50 A.M.	9.0 ,,	B.
23...	W. by S.	2	S.S.E.	2	S.W. by S.	4	0.30 P.M.	4.0 ,,	B.
27...	N.	0	E.	3	E.	0	Noon.	...	V.
28...	E.	0	E.	4	S.S.E.	2	No change.	8.0 ,,	...
29...	S.E.	2	S.E.	2	S.E.	0	No change.	No change.	...
30...	S.S.W.	2	S.E.	2	S.S.W.	3	3.15 P.M.	8.0 P.M.	B.

June.

1870.	Wind at 6 A.M. Direction.	Force (0–12).	Direction from which sea breeze blew.	Force (0–12).	Wind at midnight. Direction.	Force (0–12).	Towards E.S.E.	Away from E.S.E.	Whether it veered (V) or backed (B) towards E.S.E.
3...	N.E.	0	E.S.E.	3	S.E.	0	8 A.M.	7.0 P.M.	V.
5...	S.E.	0	(N.)	2	N.	0	No change.	No change.	...
8...	N. by W.	2	{E.N.E. / E.}	2	W.	4	{1.20 P.M. / 2.40 ,,}	6.10 P.M.	V.
14...	S.W.	2	S.E. by E.	2	N.W.	0	1.40 ,,	3.0 ,,	B.
21...	W.N.W.	2	W.	0	W.	0	No change.	No change.	...
22...	W.	0	N. by E.	2	N.	0	11 A.M.	11.0 P.M.	V.
23...	N.W.	3	N.W.	2	N.W.	0	No change.	No change.	...

ad Register.

April.

At North Lighthouse, 200 feet above the sea.

Wind at 9 A.M. Direction.	Force (0–12).	Wind at 3 P.M. Direction.	Force (0–12).	Thermometer in shade. 9 A.M. Dry.	9 A.M. Wet.	3 P.M. Dry.	3 P.M. Wet.
				°	°	°	°
S.W.	3	S.S.W.	1	47·8	45	55	50
N.W.	3	N.W.	1	46	44	43	41
W.S.W.	0	S.E.	4	45·5	42·2	48·5	43
S.W.	4	S.E.	5	47·5	39·8	46	42
S.W.	5	S.E.	4	50·8	43·5	49·5	43·2
Calm.	0	N.	2	48·8	42·5	53	43
N.W.	3	N.W.	4	48	44	53·5	47
N.	4	S.E.	2	45	43	45	41·8
N.W.	3	N.N.W.	1	50	46·2	56	47·5
N.W.	2	E.S.E.	2	55	47	53·5	47·5
S.	2	S.E.	5	54·8	48·5	45	43·5
S.	4	S.S.E.	4	44·2	43	43	42
S.E.	4	S.E.	3	39·5	39·5	47·5	45
S.E.	3	N.	4	56·8	50·8	63	54

May.

N.W.	4	N.E.	5	46·2	43·2	43·8	42
N.W.	3	Calm.	0	49·5	47	53·2	50
N.N.W.	1	N.N.W.	1	47·2	45·5	49	47
S.	1	S.E.	4	50	46·5	50	44·8
S.	1	E.S.E.	3	48·2	44·8	49·8	44·8
Calm.	0	S.E.	3	54·5	52·2	52	52
S.W.	1	E.S.E.	2	52	50	55	52·2
E.	1	S.E.	3	51·2	50·5	51	51
S.E.	2	E.S.E.	3	49·8	48·2	51	49
S.E.	5	S.E.	4	51·5	50	50	49·2
S.	2	S.E.	5	62·2	58	60	56·8

June.

E.S.E.	2	S.E.	3	50	48·5	48·5	48·2
N.W.	1	N.N.W.	1	53·5	52	55·2	53·8
N.	4	E.S.E.	2	51	49	60·2	49·5
N.	1	S.E.	1	61·5	58·2	63	68·8
N.W.	3	W.N.W.	1	68	66	68	67
N.W.	1	N.	1	69·8	68	65	64
N.N.W.	5	N.N.W.	3	55	53·5	55·2	53

TABLE I.

July.

At Hawsker, 340 feet above the sea, 1 mile from sea.

1870.	Wind at 6 A.M. Direction.	Force (0–12).	Direction from which sea breeze blew.	Force (0–12).	Wind at midnight. Direction.	Force (0–12).	Time at which Wind changed: Towards E.S.E.	Time at which Wind changed: Away from E.S.E.	Whether it veered (V) or backed (B) towards E.S.E.
7...	W.S.W.	4	E.	2	E.S.E.	0	Noon. 1.45	8 P.M.	V.
8...	W.S.W.	2	(N. by W.)	2	N. by W.	2	11.50 A.M.	...	V.
9...	N. by W.	3	E.S.E.	4	E.S.E.	0	Noon.	...	V.
11...	N.W.	3	E.	3	N.E.	0	11 A.M.	11.20 P.M.	V.
13...	N.N.W.	0	N.E. by N.	2	W.	3	1 P.M.	5 P.M.	V.
14...	W.	3	E.	5	S.S.E.	0	Noon.	3 P.M.	V.
19...	S.W.	5	N. by W.	2	W.N.W.	3	11.30 A.M.	10 P.M.	V.
20...	W.	2	E.S.E.	3	S.W.	4	11.30 „	1.55 P.M.	V.
22...	W.N.W.	2	E. / E.S.E.	4 / 4	S.	2	0.30 P.M. / 1.30 „	8 P.M.	V.
23...	S.W. (3 to 5 A.M. S.S.W.)	3	E. / E.S.E.	3 / 5	S.E.	3	11 A.M. / Noon.	Gradually.	B.
24...	S.S.E.	2	E.S.E. / S.	4	E.	3	8 A.M.	7.10 P.M.	B.

August.

5...	S.E.	0	E.	3	S.S.W.	2	11.30 A.M.	5.5 P.M.	B.
6...	S.S.W.	0	E. by N.	4	E.S.E.	2	10 A.M.	8 to 10 P.M.	B.
7...	E. by S.	2	E.	3	E.	2	No change.	No change.	...

From the 9th to the 18th inclusive the weather was fine, though not warm;

September.

6...	S.W. by S.	2	E.S.E.	2	S.W. by S.	2	3 P.M.	4 P.M.	B.
7...	S.W. by S.	2	...	2	W.S.W.	3	...	5 P.M.	...
11...	N.W. by W.	2	E.	2	S.W.	3	3.10 P.M.	8 to 9 P.M.	V.
15...	N.N.W.	0	N. by E.	2	S.	2	11 A.M.	8 P.M. / 11 P.M.	...
18...	N.E.	2	E.N.E.	4	S.	2	11 A.M.	11 P.M.	V.
19...	S.W.	3	...	4	S.W.	2	...	...	...
21...	W.S.W.	0	N.N.E.	3	S.	2	3 P.M.	9 P.M.	V.
22...	S.	0	E.	4	S. by W.	2	Noon.	11 P.M.	B.
23...	S.S.W.	2	E. / E.S.E.	5	E.S.E.	2	11 A.M. / 1 P.M.	...	B.
24...	S.S.E.	3	E.S.E.	5	S.	2	11 A.M.	9 P.M.	B.
25...	S. by W.	0	E.	4	S.E.	2	11 A.M.	10 P.M.	...
26...	S.E. by E.	0	S.E.	2	S.E.	0	No change.	No change.	...
29...	N.E.	2	N.E. by E. / E.	0	E.	0	10 A.M.	No change.	V.
30...	S.	2	E.	4	E.	2	Continued calm till noon, 4 P.M.	...	B.

ontinued).

July.

At North Lighthouse, 200 feet above the sea.

).	Wind at 9 A.M. Direction.	Force (0—12).	Wind at 3 P.M. Direction.	Force (0—12).	Thermometer in shade. 9 A.M. Dry.	9 A.M. Wet.	3 P.M. Dry.	3 P.M. Wet.
					°	°	°	°
.	N.W.	3	S.E.	3	59	57	62·5	56·8
.	S.W.	1	W.	1	71	65	63	61·8
.	S.E.	1	E.S.E.	3	68	65	60·5	60
.	E.	1	E.S.E.	2	64·5	61	63·5	61·8
.	N.	3	E.	1	58·8	56·2	61·8	57·8
.	N.W.	1	S.E.	3	63	57·5	63·8	57
.	W.S.W.	4	Calm.	0	72·8	67·2	67·2	62·5
.	Calm.	0	W.	4	63·2	58·5	72·8	63
.	N.E.	1	S.E.	4	62	58	64	51
.	S.	3	S.E.	5	74·5	62·5	61·5	59·8
..	S.E.	4	S.E.	5	61·8	59	61·8	58·8

August.

..	S.E.	1	S.E.	3	64	58	61	58
..	Calm.	0	S.S.E.	4	62	57	62·8	57·5
..	S.E.	1	S.E.	4	62·5	59·5	63	59

the wind continued unchanged all day between N.N.W. and N.N.E.

September.

..	S.	4	S.W.	3	58·5	54	60	55
..	N.W.	5	N.	4	54	51	56	53
..	S.W.	4	W.	5	51	50	60·2	54
..	W.S.W.	4	W.S.W.	3	50	47	56	54
..	S.W.	5	S.W.	3	55·5	53	64·5	58
..	S.W.	4	W.S.W.	3	60	56·5	66	60·5
..	S.W.	2	S.E.	4	62·2	58	58	57
..	S.S.E.	4	S.E.	5	56·2	54	57·5	56
..	S.S.E.	4	S.S.E.	3	57·5	55	57	55
..	S.S.E.	3	S.E.	4	56	54·8	56·5	56
..	S.	2	S.S.E.	4	60	56	59·8	58·2
..	N.W.	2	Calm.	0	57	56·5	57·8	57
..	S.W.	2	S.S.E.	5	53·2	52	57	55
..	S.S.W.	1	S.E.	4	53	51·5	56	53·5

TABLE I.—

April.

At Hawker, 340 feet above the sea, 1 mile from sea.

1871.	Wind at 6 A.M. Direction.	Force (0–12).	Direction from which sea breeze blew.	Force (0–12).	Wind at midnight. Direction.	Force (0–12).	Times at which Wind changed: Towards E.S.E.	Times at which Wind changed: Away from E.S.E.	Whether it veered (V) or backed (B) towards E.S.E.
7...	S.	2	E.	3	E.	0	1.10 A.M.	...	B.
8...	E.	0	E.N.E.	2	S.E.	0	...	...	...

May.

21...	N.	0	E.	2	S.	2	2 P.M.	10 P.M.	V.
22...	S.W.	2	E.	4	S.S.E.	2	11.10 A.M.	11 P.M.	B.
23...	S.E.	3	E.S.E.	4	S.E.	2	9.50 A.M.	5 P.M.	B.
24...	S.E. by E.	2	E.S.E.	4	S.E.	2	9.45 A.M.	6 P.M. 1.30 A.M.	B.
25...	S.S.W.	2	E. by S.	4	S.S.E.	0	7 A.M.	2 P.M.	B.

June, [illegible]

July.

10...	S.W.	2	E.	2	S.E.	2	1 P.M.	...	V.
12...	N.W.	4	E.	2	S.W.	2	3 P.M.	4.30 P.M.	...
13...	...	...	...	...	S.S.W.	3	...	...	V.
16...	W.	4	E.	3	N.W.	3	2 P.M.	6.15 P.M.	V.
18...	S.W. by W.	2	(N.N.W.)	0	N.N.W.	0	1 P.M.	...	V.
27...	N.W.	5	E.	2	S.E.	0	2 P.M.	6 P.M.	V.
30...	S.W.	2	E.	3	W.N.W.	0	1 P.M.	5.25 P.M.	B.

August.

1...	S.W. by S.	2	N.E.	0	N.W. by W.	0	2 P.M.	5 P.M.	V.
2...	N.W.	0	W.S.W.	0	W.S.W.	0	...	...	...
7...	N.W. by W.	4	E.S.E.	5	S.S.W.	3	1.5 P.M.	8 P.M.	B.
8...	S.W. by S.	2	E.S.E.	5	S. by W.	3	10 A.M.	10 P.M.	B.
9...	S.W.	0	E.S.E.	4	S.S.W.	3	9 A.M.	8 P.M.	B.
10...	S.W.	2	E.S.E.	4	S.S.W.	3	1 P.M.	8 P.M.	B.
11...	S.W.	2	S.E. by E.	4	S.S.W.	2	2.30 P.M.	5 P.M.	B.
12...	S.W. by S.	0	S.E. by E.	2	S.W. by W.	0	Noon.	6 P.M.	B.
13...	S.W. by W.	0	(N.N.W.)	3	N.N.W.	0	9 A.M.	No change.	V.
14...	N.N.W.	0	E.	2	S.W.	2	1 P.M.	9.45 P.M.	V.
15...	S.W.	0	N.N.E.	0	N.N.E.	0	0.30 P.M.	No change.	V.

September, [illegible]

tinued).

April.

At North Lighthouse, 200 feet above the sea.							
Wind at 9 A.M. Direction.	Force (0–12).	Wind at 3 P.M. Direction.	Force (0–12).	Thermometer in shade.			
				9 A.M. Dry.	9 A.M. Wet.	3 P.M. Dry.	3 P.M. Wet.
				°	°	°	°
W.	4	S.E.	5	43·5	37·2	43	40
W.S.W.	1	E.S.E.	4	43	40	44·5	40·8

May.

E.S.E.	2	S.E.	4	55	48	52·2	47·2
S.W.	1	S.E.	4	65	55	55	48
S.E.	5	S.E.	4	47	46	50	48
S.E.	3	S.E.	5	51	46	54	51
S.E.	4	S.W.	3	53	50	60	57·5

l weather.

July.

W.	3	S.S.E.	5	62	56	58	55
N.N.W.	4	N.W.	1	59	53·8	63	57
S.W.	5	S.W.	5	60·5	58·5	68·5	62
N.W.	4	S.S.E.	3	64	57	62	56
W.	4	N.N.W.	2	61	56	63	56
N.W.	5	S.S.E.	2	58	53	59	54
S.	3	S.	1	58	55	57	54

August.

W.	3	E.	1	60	55	62	55
S.W.	2	Calm.	0.	66	60	63	59
S.W.	4	S.E.	5	69	62	66	60
S.E.	4	S.S.E.	4	61	59	56	55
S.	2	S.E.	4	67	61	68	62
S.	2	S.S.E.	4	75	66	72	63·5
S.S.W.	2	S.E.	4	71	64·5	77	67
W.	1	S.S.E.	1	68·5	64	68	63
N.W.	2	N.N.W.	3	65	60	63	60
N.N.W.	3	N.E.	2	60	58	62	59
N.	4	N.E.	4	59·5	57·2	60	58

l weather.

TABLE II. General Summary.

Month.	Number of fine days.	Number of times sea breeze, E. to S.S.E., blew.	Number of times Northerly breeze blew.	Number doubtful. No change.	Number of times no true sea breeze.	Number of times land breeze blew at night.	Temperature. Mean, on fine days, of Dry. 9 A.M.	Wet. 9 A.M.	Dry. 3 P.M.	Wet. 3 P.M.	Daily maxima.	Approximate temp. of sea's surface.	Diff. of land and sea.
1870.							°	°	°	°	°	°	°
April	14	10	2	0	2	2	46·7	44·2	50·1	45·3	58·5	45·0	13·5
May	11	6	2	1	2	2	51·1	49·6	51·4	49·0	60·9	48·0	12·9
June	7	3	1	2	1	1	58·4	56·4	59·3	58·0	69·3	51·0	18·3
July	11	8	3	0	0	6	65·3	60·9	63·8	59·1	73·6	56·0	17·6
August	12	2	0	1	9	0	62·8	58·2	62·3	58·2	67·1	57·6	9·5
September	14	8	3	1	2	2	56·0	53·5	58·7	55·9	65·1	56·0	9·1
1871.													
April	2	2	0	0	0	2	43·2	38·6	43·7	40·4	52·4	43·0	9·4
May	5	5	0	0	0	0	54·2	49·0	54·2	50·3	63·7	46·5	17·2
June*	...	...	...	...	...	...	...	...	...	...	...	...	...
July	7	5	1	0	1	4	52·8	48·7	53·8	49·2	66·0	54·0	12·0
August	11	7	3	0	1	8	65·6	60·2	65·2	60·1	73·7	56·0	17·7
September*	...	...	...	...	...	...	...	...	...	...	...	...	...

* No settled weather.

ADDRESS

DELIVERED BY

THE PRESIDENT, J. W. TRIPE, M.D.,

AT THE

ANNIVERSARY MEETING, JUNE 18, 1873.

ENTLEMEN,—Before quitting the Presidential Chair I propose making brief statement of the progress of the Society during the last two years, ıd of directing your attention to some of the important changes which ıve been carried out in that period. For some time past there has been strong feeling amongst some Members of the Council that this Society ıould have a room in which to place the Library, and that a gentleman ho could act as Assistant Secretary and Librarian should attend there ıring ordinary business hours. This was considered by a majority to ıtail an expense which the Society could not afford; and it was only hen the number of Fellows fell off, in consequence of the deaths and signations exceeding the admissions, that it was fully discussed. That ıese arrangements were not carried out too soon is shown by the admis- on of Fellows having been reduced from 23 in 1869–70, to 13 in 1870–71, ıd to 3 in 1871–72. Under these circumstances the Council determined take a room at No. 30 Great George Street for the Library, which is ow, and has been for some time past, available for the Fellows, although is to be regretted that there has not been a larger attendance. I am lad, however, to say that of late the Fellows go there more frequently, ıd doubtless will do so to a far greater extent when it is generally nown that they can read there, and borrow books, at all reasonable hours uring the day. I may mention here that the Library contains a consider- ble number of manuscripts, some of which have been presented during this ession; I refer now to the manuscript meteorological journals of the te A. Edwin, Esq., for the years 1815–71, and of Miss Molesworth, of obham, for 1825–67. There are also a large number of works on eteorology and other kindred sciences, which may be usefully consulted y those who desire to have a good knowledge of what has been published ı the subject. I state this at some length as until quite lately but few ellows have availed themselves of these privileges. There is also another atter for congratulation, viz. that the admissions during the Session now ncluding have been larger than for many years, as no less than 35

gentlemen have been elected Fellows, many of whom are well known in the scientific world. The average attendance at the Meetings of the Society has also been larger during the last two Sessions than formerly, the smallest number during this Session having been as large as the greatest in 1870–71. The means for all the Meetings were as follows:—viz. 24 in 1870–71, 26 in 1871–72, and 32 in 1872–73.

A comparison between the opinions expressed and the facts stated at our Meetings when compared with those of the foreign observers at the Leipzic Conference is, I think, very favourable to English meteorologists. For instance, the conclusions arrived at abroad that there is not any reliable maximum or any good mercurial minimum thermometer, do not accord with the observations and comparisons so accurately made by many Fellows of this Society. I do not propose quoting any of the conclusions arrived at by those who took a part in the discussions at our Meetings, as the printed short-hand writer's notes speak for themselves; but I feel assured that the results arrived at here, and the replies which we hope to receive from the Fellows at large, will have considerable weight, not only here, but abroad. If, therefore, we have done any thing during this Session to settle such elementary matters in Meteorology as the value of aneroids for recording the ever-varying pressure of the atmosphere, the best form of maximum and minimum thermometers, and the hours best suited for recording thermometric observations so as to obtain true mean temperatures, we have made some advance towards constituting our branch of study into a science. At present ours is but a study or experimental science, and much work must be done by observers and by the discussion of observations before we can hope to place Meteorology by the side of Astronomy.

There are some proposed alterations of the Bye-laws of the Society to which I must draw your earnest attention, viz. the payment of an Admission Fee, the alteration in the amount of the Composition Fee from £10 to £12 or such other sum as you may determine, and the change of month for the Annual Meeting from June to January. As regards the proposition for the payment of an Admission Fee, I may mention that for many years there was an Admission Fee of a similar amount to that now proposed, which was withdrawn on the supposition that more Fellows would join the Society if the Annual Subscriptions only were payable; but I do not think that the alteration has had the desired effect. As to the Composition Fee, although the rate, viz. a sum amounting to ten annual payments, is that ordinarily adopted by Scientific Societies, yet it is certainly too small to keep the proper ratio between those Fellows who prefer paying the Composition and those who decide on paying annually. As regards the change of time for the Annual Meeting, I feel assured that it will be of great advantage to the Society for our financial and sessional years to correspond. There will not be any difficulty as regards the Transactions; for the publication of the papers read in November and December can be postponed to January, so as to constitute the first number for the year. There is, however, one matter which will have to be

arranged, viz. the length of time which those gentlemen who will be elected this evening shall hold office; and it will be for you to decide whether or not they shall go out in January next or at some other period.

Before concluding, I desire to express my regret at the resignation of the two Secretaries, and especially of Mr. Glaisher, who has so long and ably assisted the Society; but it is with pleasure that I have to state their continuance on the Council. I also have to express my thanks to the Members of Council and to the Fellows assembled in General Meeting for the kind support they have afforded me in the Chair.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

MARCH 19th, 1873.

Ordinary Meeting.

JOHN W. TRIPE, M.D., President, in the Chair.

Admiral Sir EDWARD BELCHER, K.C.B., 13 Dorset Street, Portman Square, W.; WILLIAM F. DENNING, Hollywood Lodge, Cotham Park, Bristol; EDWARD MICHAEL EATON, 119 Crookes Road, Sheffield; ROBERT J. LECKY, F.R.A.S., 3 Lorton Terrace, Notting Hill, W.; JOHN RICKETT, 4 Dingwall Villas, Dingwall Road, Croydon; ARCHIBALD SLATE, Chiswell Street, E.C.; LANCELOT TURTLE, Aghalee, Lurgan, were balloted for, and duly elected Fellows of the Society.

The names of two Candidates for Admission into the Society were read.

The PRESIDENT informed the Meeting that at the last Meeting of Council a letter was read containing Mr. Glaisher's resignation of the Secretaryship, and that, after much consideration, the Council had accepted it with great regret; that they had then appointed Mr. Cator to the vacant office for the remainder of the session, and elected Mr. Glaisher to the seat on the Council thus rendered vacant, which he was glad to say Mr. Glaisher had accepted.

The following papers were then read:—

"On some Results of Weather Telegraphy." By Robert H. Scott, M.A., F.R.S. (p. 181).

Captain COLOMB wished to ask if, when there is want of fulness in the telegrams, any steps are taken by letter to rectify the omissions, as, although a letter would be too late to be used in forecasting, such information might be very valuable in establishing theories of weather changes.

Mr. STRACHAN thought the public would gladly hail a return to Admiral Fitzroy's storm-signals, and he was glad to hear the Director of the Meteorological Office publicly state that he was favourable to the adoption of the "cone." The "drum" gives no indication of direction; but the cone signifies that the gale is to be from the tropical or from the polar direction, and therefore gives more precise information. Forecasts of weather had been discontinued, yet they had been listening to a great deal about the prediction of storms, which was more difficult and hazardous than forecasting ordinary weather. Mr. Scott, in a recent lecture at the Royal Institution, had asserted that the chances of the same kind of weather continuing for another day increased with its duration; and, although this doctrine might logically be pushed to an absurdity, it was nevertheless true that we have frequently long spells of the same type of weather. Therefore, according to the theory of probabilities, it is easier to predict weather from day to day during spells of fine, overcast, or rainy weather, than to foretell a storm two days in advance. There could be no question as to the advantage to the agricultural interests of the country that announcements of spells of drought or rain, fine or overcast weather (say in May or August) would be. As regards the checking of storm-warnings, as the public are told that the present system announces only facts, it is hardly

possible for the signals ever to be wrong, and any check upon them seems altogether unnecessary.

Captain TOYNBEE stated that telegrams from the Azores would be of great use if connected by intermediate stations with others from Iceland. He added, that it was sometimes useful to express wants which, at the time, appeared to be impossibilities; and he felt sure that Mr. Scott would agree with him when he said that the power of successfully warning our coasts would be greatly increased if the observations from the Azores and Iceland were connected by a line of vessels moored in the Atlantic. Practical men (and he saw Captain Colomb present) must not suppose that he dared to hope that the suggestion would be carried out; *they* were the best judges on such points. He added that he had found observations from the Azores very useful when working at the Atlantic data about the time that the 'City of Boston' was lost, because *then* ships' logs connected them with those of Iceland: but if it is necessary to wait for ships' logs, postal communication is as good or better than telegraphic.

Mr. SCOTT stated, in reply to Capt. Colomb, that it was not the general rule to receive supplementary reports from the telegraphic observers by post, inasmuch as the continuous records at the observatories and at other stations rendered such a practice superfluous. On certain special occasions, however, the observers were directed to send up to London a copy of all the observations they had recorded within a certain period. In reply to Mr. Strachan, he did not mean to imply that he was prepared to adopt Admiral FitzRoy's system at once; all that he meant to convey was, that he expected that the result of the deliberations of the Subcommittee, consisting of MM. Buys Ballot, Neumayer, and himself, appointed at the Leipzig Conference, would be to adopt some form of signals similar to Admiral FitzRoy's. He further stated that the necessity for checking the intelligence issued had been forced upon the Office by an order by the House of Commons for a return for 1870, and that the Office had found great benefit from the preparation of that return, and had continued the practice.

"On the Barometric Depression of January 24th, 1872." By William Marriott, Assistant Secretary (p. 188).

The PRESIDENT expressed his satisfaction with Mr. Marriott's paper, and considered the figures showed that great care had been used in compiling them. It was remarkable what slight changes had occurred in the barometrical readings at the points of lowest depression as the storm swept across England: thus, at midnight the lowest reading was 28·42 in., at 1 A.M. 28·32 in., at 2 A.M. 28·26 in., at 3 A.M. 28·21 in., at 4 A.M. 28·26 in., at 5 A.M. 28·19 in., at 6 A.M. 28·21 in., at 7 A.M. 28·31 in., at 8 A.M. 28.28 in., and at 9 A.M., as it passed out of the country, 28·25 in. He thought these and other similar tables would be found to be very useful when printed, for purposes of comparison in the future; and hoped that the Transactions would eventually become such a mine for reference as would render unnecessary the searching of numerous volumes for information on storms and other meteorological phenomena.

Captain TOYNBEE was very much interested in the fact that the speed of the depression was about 30 miles an hour. In the discussion of the meteorology of the Atlantic, he found the rate of progress of several gales to have been from 30 to 40 miles an hour. He thought that, considering the small number of observations, the subject had been very carefully worked out.

Mr. SCOTT said that it was very satisfactory to him to find that the results as to the track of the storm which had been obtained in the Meteorological Office had been entirely confirmed by Mr. Marriott from the information derived from a more copious supply of data. As regarded the remarkably low barometrical readings to which attention had been drawn, he would remark that Mr. Marriott, if he had looked forward instead of backward, would, as every one knew, have found readings about equally low in January of the present year. In this connexion it might be interesting to the Society to mention some very low readings which had been brought under his notice of late. It would be remembered that on the 5th February, 1870, the reading of 27·33 in. had been recorded on board the Cunard steamer 'Tarifa,' in 51° 3′ N., and 23° 59′ W.: and in these islands this extraordinarily low reading had been nearly equalled. Prof. Thomson, of Aberdeen, had informed him that on January 7th, 1839, a night when those who were old enough to remember it would have expected an extraordinary reading, his predecessor, Dr. Knight, had registered the very low level of 27·56 in., the barometer having fallen 1·79 in. in

24 hours. Furthermore Dr. Robinson, of Armagh, had cited as his lowest reading 27·608 in. on the 28th November, 1838. On this occasion the barometrical readings at the Ordnance-Survey Office, Dublin, had ranged below 28 in. for 24 hours, and, as might be expected with such an extensive depression, there had been no storm. It was remarkable that these two extraordinary depressions had occurred within about six weeks of each other, and it was evident that in the winter of 1838–39 the atmosphere had been in a very disturbed state.

Mr. SYMONS said he should be glad to see the two facts Mr. Scott had referred to printed in the discussion on the paper, as they would tend to make it very interesting. He gathered, however, from the paper, that Mr. Marriott had limited his notices of previous depressions to those observed in the vicinity of the Metropolis; and it was well known that in the north and west of Scotland low readings were much more frequent. Mr. Scott had mentioned that there was another depression at Valencia at the same time; he (Mr. Symons) thought that there were three, the two subsidiary ones having (at 9 A.M. on the 24th) their centres respectively on the west or south-west of Ireland and the north-west of the Hebrides.

Dr. MANN said he should like to ask Capt. Toynbee if he did not know any instance in which the rate of 30 miles an hour had been exceeded? In the storm which wrecked the 'Athens' mail steamship in Table Bay in May 1865, the greatest depression of the barometer passed from Table Bay to Maritzburg, in Natal, a distance of 800 miles, in 20 hours, and therefore apparently at a rate of 40 miles an hour (see Proceedings of the Meteorological Society for Feb. 1867, p. 349).

Capt. TOYNBEE said that Mr. Meldrum, in his "Meteorology of the Indian Ocean," stated that their rate of motion in the southern hemisphere was about 20 miles an hour. Probably, in the case mentioned by Dr. Mann, there were two minima, one following the other, and that he at Natal was not dealing with the one which had passed over the Cape of Good Hope 20 hours before. When the state of the atmosphere is disturbed, it is customary for these depressions to follow each other quickly.

Mr. STRACHAN said the investigation had been so well done that it called for very little comment. It had suggested to him, however, the desirability of investigating, in a similar manner, the low atmospheric pressure of January last. Mr. Scott had mentioned a barometric depression as happening exactly two months after a previous one. Curiously enough, just thirty days after the remarkable depression, 28·49 inches, on January 19th last, the remarkable barometric maximum of 30·8 inches occurred on February 18th. The depression of the 19th, which extended from the north of Scotland to the south of France, and to about an equal extent eastward and westward, was well marked for four or five days, almost stationary, and accompanied with very little wind. It seems, therefore, to present features in marked contrast to the characteristics of the depression of January 1872, which was virtually a cyclonic disturbance. It would be an important object to endeavour to account for the large quantity of air, nearly one-twentieth of the superincumbent atmosphere, which was displaced from this enormous area. Whither did it go? and what caused it?

Mr. BIRT said he would supplement the remarks of Mr. Strachan by calling attention to the fact that great depressions of the barometer had occurred about the middle of January during the last five years. He would congratulate Mr. Marriott on his paper, and especially on the construction of hourly isobars, which were very important in the investigation of such phenomena. From the 'Quarterly Weather Report' it appeared that there were three minima or minor depressions in the lowest portion of the concavity of a wave of low pressure which traversed the area from the 20th to the 27th of January; of these the one in question was the deepest.

Mr. WHIPPLE thought that a depression like the one under discussion enhances the value of self-recording instruments, because observers might not be aware of the fact that one was passing over them, and omit to take eye-readings. After a depression of the barometer, he had observed that there was usually a sudden jump at the time elevation commenced; and by comparing the times at which the jumps occurred at different stations, the rate of motion of the column of minimum pressure might be obtained. In most cases the jump is accompanied by a change in the direction of the wind, and hence the time of its passage might probably be deduced from anemograph records where baregrams do not exist. He believed the rate of motion of depressions to be about 30 miles an hour. Self-registering instruments, by recording consecutive depressions, remove the source

of error to which observers distant from each other are liable, viz. considering two or more as one and the same depression.

The Meeting was then adjourned.

APRIL 16th, 1873.

Ordinary Meeting.

JOHN W. TRIPE, M.D., President, in the Chair.

CHARLES OCTAVIUS BUDD, M.A., 19 Craven Street, and ALEXANDER E. MURRAY, Manor House, Hastings, were balloted for, and duly elected Fellows of the Society.

The names of three Candidates for Admission into the Society were read.

The following papers were taken as read:—

"On a Proposed New Form of Rain-Gauge, 'The Atmospileometer.'" By John James Hall, F.M.S. (Abstract.)

This instrument consists essentially of two parts—(1) a large cylinder, closed at the bottom, which contains a strong glass bottle for the reception of the water, and (2) a receiver, funnel, and condenser combined. The receiver consists of an upright or vertical sharp-edged copper cylinder, the internal diameter of which is 8 inches, in the inside of which a funnel is fixed. To the bottom of the funnel is attached a spiral tube, consisting of about four turns, and terminating in a long straight tube, the bottom of which dips into, and serves to convey the water to, the bottle. A second spiral tube is turned within the helices of the first, which passes at the top through a cylinder enclosing the tubes, and terminates under the funnel, the lower end passing straight down, side by side with the other tube, into the bottle. This serves to convey the air from the bottle, and allows the rain to pass freely into the bottle instead of remaining in the funnel and tube, and so being liable to evaporate.

The cylinder enclosing the two spiral tubes is about ¼ of an inch larger in internal diameter than the circle described by the exterior surface of the tubes; the whole of this space and that between the tubes is filled with wet sand. On the lower end of the cylinder a stopper-box is screwed, within which is a spiral spring and indiarubber pad which, by its downward pressure, completely closes the bottle to the passage of air or water, except by the tubes *which pass through the stopper.*

The author believes that the two tubes presenting as they do so much condensing surface, and being kept cool by the wet sand that surrounds them, would prevent evaporation. Should any aqueous vapour arise, it would accumulate and, when condensed in sufficient quantity, descend again into the bottle.

"Note on a Circular Rain-Gauge Level and Tester." By John James Hall, F.M.S.

This consists of a circular spirit-level placed on the centre of four horizontal cross arms, underneath each of which pins or stops are fixed, the outer sides, *i.e.* furthest from the centre of the spirit-level, being set at 2·50 and 4·00 inches from the centre, thus describing, from their outer (vertical) surfaces, equidistant from the centre of level, different diameters of circular rain-gauge receivers which, in the instances I have given, would represent 2·50 × 2 = 5·00 inches, and 4·00 × 2 = 8·00 inches. Pins may be set for any number of diameters: I simply mention the foregoing as sizes generally recognized.

In using this instrument to determine the level of a gauge, it is simply necessary to drop the pins or stops within the rim of the receiver, thus allowing the horizontal arms to lie flat on it; the spirit-level will then stand in the exact centre of the gauge, which, if in error, may be truly set in every direction by tilting it until the bubble rests in the centre of the level.

This instrument answers a second purpose. By turning it round while in use, it will prove the circle of the receiver—a matter not to be lost sight of, especially when constructed on the sharp-edged vertical principle.

The discussion on some of the Questions proposed to the Leipzig Conference was then commenced.

The PRESIDENT stated that as the questions for discussion were numerous, he was obliged to limit the time to be allowed to each speaker to five minutes.

He then read the first Question (No. 2 of the Report of the Leipzig Conference) :—

"What is the best form of Barometers for stations of the second order? Is the use of Aneroids for such Stations admissible?"

He remarked that the decision of the Leipzig Conference had been that Dr. Hann was to undertake the duty of reporting on this question.

Mr. SYMONS. I think a previous decision was arrived at, viz. to the effect that aneroids should not be used instead of mercurial barometers, but only for interpolation and as auxiliary thereto. All I wish to call attention to is the general remarks in respect to aneroids. Several speakers seemed to assume that aneroids were likely to get out of order; and I rise to ask those present whether they can confirm an opinion in respect to the aneroid adverse to that which was enunciated at Leipzig? I may say that I have used aneroids a great deal, and I am aware that they do sometimes play tricks; still they are good instruments, and employed by a great many persons. As an illustration of the good work to be got out of aneroids, I may mention that I have two which I tested and compared with my standard barometers before starting on a long tour through Devon and Cornwall. I compared them upon Dartmoor, and with nearly a dozen standard barometers in those counties, and found that only one standard barometer gave an error of above 0·03 in. when tested by my aneroids; and I proved afterwards that that one barometer was itself wrong. This is one instance why I cannot concur in the sweeping accusation against aneroids.

Mr. WHIPPLE. In respect to barometers for stations of the second order, I think we require to know exactly what are stations of the second order,—whether they represent stations where observers can take frequent eye-observations, or where they take only one observation *per diem*. If it is where they take frequent observations, give a closed cistern barometer, in which the scale is contracted to correct for change of zero. If, on the other hand, it is supposed that observers at these stations can only make one observation a day, I think they had better be provided with registering barometers of the Milne pattern: this instrument is working, I believe, at one or two of the Meteorological Committee's stations; but I am not able to speak of its actual performance. My opinion is that something after that construction might be made to answer for these stations. The principal feature in it is a pencil supported by a float, with a clockwork arrangement, which drives it, at definite intervals, against a sheet of paper. I think eventually we shall obtain an electric apparatus acting upon this principle. With respect to aneroids, there is one point which seems to have been overlooked. As observing instruments, they work very well if only subjected to ordinary atmospheric changes; but if subjected to great variations, they will be found to vary considerably. I have no doubt, however, that, if used only as observatory instruments, they may be relied upon during the intervals which elapse between comparisons periodically made by the Inspector of Observatories, who should carry a mercurial barometer on his rounds, or when the mercurial barometers, if such are employed, should get out of order.

Dr. MANN. In reference to the character of the aneroid, I think it right to say that my experience of the instrument is that it is only of scientific value when subjected to frequent comparison with some good mercurial barometer. The chief ground upon which this opinion is formed is that during some time Capt. Grantham, of the Royal Engineers, when engaged upon a military survey in the colony of Natal, for a long period, sent several good aneroids, which were used in rough moving work, in continued succession, to me, for comparison with the fixed mercurial standard of my observatory, and that it scarcely ever happened that an instrument came in for comparison which had not acquired an error of a tenth part of an inch. I believe the aneroid barometer is liable to mechanical derangements when in rough moving work, which no care in handling can guard against with absolute certainty, and that these derangements are of a class which does not affect the mercurial form of the instrument.

Mr. CASELLA. I gather from the discussion that aneroids, however good, may at any time become deranged without its being known, and so always require to be compared with a standard mercurial barometer. I much fear then that, for the purpose proposed, aneroids are not desirable instruments to act with.

Mr. STRACHAN. The Meteorological Office issues a large number of aneroids to H.M. ships. When they go out they are set to the standard barometer reduced to

32°; and when they come back they are again compared. Their scale-errors change so much that they cannot be relied on except as weather-glasses. Even for determining heights, their readings cannot be depended upon, unless the observer takes frequent comparisons with a standard barometer. I will give you an instance. Only last week we had five aneroids returned from H.M.S. 'Nassau,' and only one was any thing like correct; one was as much as one inch out, another nearly half an inch. They were all in fair condition, and had not been tampered with, yet their indications had gone astray in this way. I should think there can be no difference of opinion in England as to the kind of mercurial barometer best suited for secondary stations; in my opinion it is the Kew pattern.

Mr. Scott. Aneroids have constantly to be compared with mercurial instruments, and therefore cannot be depended upon. As regards the "Kew" barometers, I may say that some are being made on a similar principle in France, the correction for capacity being taken into account in the scale.

Mr. Laughton. Notwithstanding the imperfections of which it is accused, I think that an aneroid on board ship is fairly to be relied on. As an instance in support of this opinion, I may say that, after the loss of the 'Captain,' I wrote to officers of nearly every ship in the squadron for copies of the barometric readings at the time. From some I received the readings of the standard barometer, from others the readings of an aneroid; and, comparing the observations, I found them agree very closely one with the other,—the differences between aneroid and barometer not being greater than those between barometer and barometer, and none exceeding what, in such a storm, might fairly be attributed to difference of position.

Serjeant Arnold said that he had a very good aneroid, bearing Negretti and Zambra's name, which had performed very satisfactorily for several years.

The President. The time has now arrived to sum up our conclusions. In the first place, the opinion of all present seems to be that for hard rough work, where the aneroid may be exposed to rapid and extensive oscillations of pressure, it is not suited for taking correct observations—as, for instance, in mountain-ranges. I can make this statement from personal observation, having been amongst the Swiss mountains myself, and seen aneroids compared both before and after an ascent, where, in many instances, the aneroids were much altered in register after they were brought down from great altitudes. Secondly, the opinion of the Meeting seems to be, that while the aneroid is well suited for taking observations when another instrument is damaged or out of order, it is not to be depended upon for taking observations at any stations unless very frequently compared with a mercurial barometer, and that the Kew barometer is very much to be preferred.

The President. The next question for us is No. 4 of the Report of the Leipzig Conference, viz., "What is the best construction of maximum and minimum thermometers?" The result of the discussion was, first, that the performance of the minimum thermometer (Rutherford's) was satisfactory, and, secondly, that there is not any maximum which could be generally recommended.

Rev. F. W. Stow. The chief thing I have to say on this point is that I took the trouble, a few years ago, to make a comparison of two different maximum thermometers. One was a Negretti and Zambra, which I have had about 15 years, and the other was one made by Casella, on Phillips's principle, which I have had for 7 or 8 years. These instruments were placed together in a louvre-board screen, with their bulbs 4 ft. above the ground. The correction applied to Negretti's was −0°·3, and to Phillips's −0°·2. Observations were taken on 90 days, viz. 26 in June, 10 in July, 24 in August, and 30 in September. The difference of the readings, when corrected for index-error, reached 0°·4 on one day only out of 90. The difference was 0°·2 four times in June, once in July, and three times in August. It was 0°·1 four times in June, three in July, six in August, and seven in September. The two thermometers agreed exactly on thirteen days in June, five in July, three in August, and eight in September. The difference was −0°·1 (that is, the Negretti read lower than the Phillips's) three times in June, once in July, eleven times in August, and ten in September. It was −0°·2 once in June and three times in September, and −0°·3 once in August and twice in September. So that the average differences were:—

June..........	+0°·04	August..........	−0°·08
July..........	+0°·04	September	−0°·09

and for the whole 90 days − 0°·018, or only $\frac{1}{55}$°. I have known Phillips's instruments

resolve themselves into ordinary thermometers; but this has been where the detached portion of mercury has been too long. I believe that if the instruments are well and carefully made on either of these principles, they are as good as can be desired.

Mr. CASELLA said, I was at a loss to conceive how the Conference at Leipzig could consider maximum thermometers defective. Certainly, some 20 years ago they were defective when they had steel indices, and we had often to rely on Six's thermometer as the standard. The use of steel indices was then supplanted by Negretti and Zambra's thermometer. When this thermometer came into use, it seemed to leave little to be desired. About this time another thermometer was devised by John Phillips, Esq., F.R.S., which is known by his name, and of which Mr. John Welsh, F.R.S., in the 'Kew Report of the British Association for 1853–54,' said, "it is valuable for its extreme simplicity; it is capable of greater delicacy of indication than even Negretti's. . . . . Any careful observer will, it is believed, find this the most convenient form of all maximum thermometers." This instrument was made and introduced into use by myself. It admits of great variation in size and form, and is extensively used for clinical thermometers. I have to tender my best thanks to the Professor for associating my name with it, as Casella's Maximum Thermometer, on Phillips's principle.

Mr. PASTORELLI. With respect to Phillips's and Negretti's maximum thermometers, both instruments require to be made with the greatest care. In Phillips's we often find that, if this be observed, the mercury column will occasionally unite with the index, when it ceases to be self-registering. This arises from the great difficulty of making thermometers absolutely free from damp. The same degree of moisture may exist in Negretti's, but there is no air-speck to derange. If Phillips's is well made, I consider it equal to Negretti's; but when we consider the difficulty of getting attention paid to any instructions when sending these instruments abroad, I prefer to send those on Negretti's principle, provided they be well made. The difficulty to overcome is to reduce the tendency to give their results by jumps or impulses. I have a standard thermometer of perfect calibre, correctly divided between the two fixed points, which I assume to be a correct instrument. If I were to send this thermometer to Kew, a difference might be found by comparison of one or two tenths of a degree; therefore, if we get maximum thermometers to register within two or three tenths, I think it very close work. Considering both Phillips's and Negretti's thermometers on their own merits, I have a difficulty to which to give the palm. I like them both very much, but I rather prefer to make them upon Negretti's principle when they are to be sent abroad, as they are not so liable to derange; but they both require great care in construction.

Mr. STRACHAN. As to maximum thermometers, Negretti's is decidedly the best, and should be used at all land-stations. If well made, it answers perfectly; and very few are not properly made. I will not speak of its merits as a clinical thermometer, as that is a matter about which we have nothing to do on this occasion. If a maximum thermometer is required for use on shipboard, Negretti's, experience shows, is not so well suited as Phillips's, which can be specially constructed for such purpose. Mr. Casella deserves the entire credit of having rendered this instrument suitable for use at sea. There an instrument is required the index of which will not shift its place, by the ordinary motion of the ship at least. Such instruments Mr. Casella constructs for the Admiralty, on Phillips's principle, by giving the tube so fine a capillary bore that the index is retained in its proper place by capillary attraction, even in opposition to gravity; so that considerable momentum must be imparted to it by shaking the instrument, holding the bulb end downward, before the index portion can be got in proper relation to the main portion of the mercury that is to set it. The instrument may be swayed about, as on shipboard, in any way, without causing the index to slip. Mr. Casella has been uniformly successful in making these instruments. Still we have had two or three instances of the air-speck getting above the mercury after long usage, and the instrument is then reduced to an ordinary thermometer. As regards minimum thermometers, as Mr. Casella himself does not recommend the general use of the mercurial minimum invented by his son, there is no choice, and Rutherford's spirit minimum must be employed on land and at sea. This thermometer answers fairly at sea, in ordinary weather, when made with a fine bore and a long index; and for use on land the only drawback is the tendency of the spirit to condense at the extremity of the tube. This much, however, I must say of Mr. Casella's beautiful mercurial instrument, that I have had one of the earliest made in constant use ever since, and it has always acted with the greatest accuracy, and I have never had any difficulty

with it whatever. Nevertheless, I can understand that, in the hands of persons inexperienced in the careful use of scientific instruments, it would prove troublesome. The chief point to attend to is the careful balancing of the instrument on its support. The bulb must not be placed too high nor too low with reference to the horizontal position.

Mr. DINES expressed his satisfaction with Phillips's thermometer.

The Rev. F. W. STOW. In 1871, I made a comparison of extremes registered by a Casella's mercurial minimum with those registered by a standard Rutherford minimum, and the result was that Casella's nearly always registered lower than Rutherford's; but the difference increased as the temperature got higher. This comparison was made at Hawsker in 1871, and the mean difference ranged as follows:—

	Mean minimum.	Daily range.
0°·20 in June	44°·8	11°·7
0·31 in July	50·0	14·4
0·49 in August	52·0	16·0
0·24 in September	48·0	10·8

Then, in 1872, I compared Casella's instrument with a smaller Rutherford minimum with elongated bulb, and the results were nearly the same. This comparison, however, was made at Harpenden, where the daily range is much greater. The mean difference was:—

	Mean minimum.	Daily range.
0°·14 in April	37°·5	18°·6
0·12 in May	42·2	17·7
0·35 in June	49·1	21·0
0·52 in July	51·9	22·6
0·56 in August	49·8	19·1
0·36 in September	46·9	17·1
0·05 in November	37·9	11·0

I conclude that, practically, the two instruments agree, with very little variation, during the colder part of the year; but that in summer the mercurial minimum registers considerably lower than the other, the difference being extremely fluctuating from day to day. The reading of Rutherford's minimum may be depended upon to 0°·5 if the mean minimum is about 45°; but if the latter exceeds 50°, the alcohol thermometer may not unfrequently be 1° wrong. I suppose the explanation is, that in the summer nights the changes of temperature are more rapid than in the long winter nights, and that the Rutherford thermometer is not sufficiently sensitive to register these changes accurately. In both experiments the instruments were placed in a louvre-board screen.

The PRESIDENT. The discussion on this subject must now close. I think we may take it that we differ very materially from the continental observers, inasmuch as we look on mercurial maximum thermometers as undoubtedly reliable when properly made on Negretti's or Phillips's principle. As far as I can ascertain, Phillips's was not referred to at all at the Congress, and Negretti's had not been fairly tried. I can bear my own testimony in favour of both instruments, and think Phillips's is rather more sensitive than Negretti's; but it requires more care. The whole discussion this evening is clearly in favour of these thermometers, and shows that they can be relied upon for giving extremely good results. It seems to be a question whether the mercurial minimum is fitted for ordinary work; but there is undoubted evidence to show that where sufficient time and care can be given, it is a reliable instrument. I also think we all agree that the Rutherford minimum is a very good one.

The PRESIDENT. The next subject for discussion is No. 5 of the Report of the Leipzig Conference—"What Instruments should be employed for determining the intensity of Solar Radiation? and in what way can the comparability of the results obtained be insured?" The conclusions arrived at by the Leipzig Conference, as stated by Mr. Scott, were—first, that the results being obtained with different instruments, they were not comparable with each other; and, secondly, that one hardly knew, with the instruments now in use, what had been actually observed. At the outset, it must be remarked that thermometers give the

maximum temperature during the day, but do not indicate the time for which it lasted, and are therefore of comparatively small value. For instance, you may get a very high temperature recorded by a temporary outbreak of the sun on a cloudy day, by which any one might be erroneously induced to record the day as unusually hot. Some plan should therefore be adopted by which the amount of heat reaching the earth could be ascertained, or else for determining with certainty the solar radiation by thermometric observations taken at very frequent intervals.

Mr. Symons. I think the discussion of this question has been anticipated by a paper read before this Society recently by Mr. Stow. Having, in my note to Leipzig, referred to this paper, my name was proposed instead of his to give a report to a future Congress on the mode adopted in this country for measuring radiation. I am afraid, if a Report is to be prepared, I shall have to draw largely upon my friend's assistance. Our President has raised the question of duration as well as intensity, which is also, I think, effectively dealt with in Mr. Stow's paper. I think we can scarcely improve on the mode of measuring terrestrial radiation, except we abolish the use of grass, and have something which is more definite and more uniform in length—something of the nature of long fleecy woollen fabrics, velvet, or sealskin. Something of known and comparable quantity of radiating-power would be a great improvement on grass.

Rev. F. W. Stow. Mr. Symons has said most of what I had to say on this subject; and I have only to refer to my two papers upon the question,—one written about four years ago, and read before this Society; the other just now about being published, an extract from which, expressing my opinion on radiation, I will read to you:—"To look at the subject generally, there are three different objects which meteorologists may propose to themselves in attempting to measure the sun's heat. The first is the measurement of the intensity of the solar rays, irrespectively of the duration of sunshine and of the angle at which the rays strike the ground. This should be measured by the excess of the reading of a thermometer with blackened bulb in vacuo, freely exposed to sun and air, above the temperature of the air in shade. The second is the total heating effect upon a large mass of earth, metal, or water, also irrespectively of the angle of incidence of the sun's rays, but depending both upon the intensity and the duration of the sunshine. This might be measured by inserting a thermometer into the centre of a hollow sphere, such as a 68-lb. shell, which might be filled with water, and should be elevated above the ground. The third is the heating-effect produced upon the earth's surface, depending upon the altitude of the sun, as well as upon intensity and duration of sunshine, not to mention moisture, evaporation, &c. This may be measured by a thermometer not *in vacuo* placed upon the ground, or still better, perhaps, by one buried just below the surface of a level sand-bed. It is to the first of these, Actinometry, that I have directed attention. I do not say that the other investigations are not equally important; but I think it best to obtain figures which represent the action, not of a variety of causes, the individual effect of each of which is unknown, but of one cause only, and afterwards to proceed to the investigation of the effects of two or more causes combined." I do not know that I can add to that, except that I think some way might be devised for finding out the heat of the surface of the ground. Does terrestrial radiation come into our subject? I certainly think we ought to do away with the use of grass.

The President. I would observe that the subject under discussion is "instruments;" and unless you consider grass an instrument, it will not properly come into discussion, however useful it may be to settle the point.

Mr. Whipple. The experience at Kew has been against the use of thermometers for determining radiation. In fact, we have decided to have nothing to do with them. There is an instrument in use called "Hodgkinson's Actinometer," which gives good results, but is a very difficult instrument to observe, and therefore cannot be recommended for use except at large Observatories. It is a species of thermometer filled with a highly dilatable liquid (ammonio-sulphate of copper); the readings obtained by it are certain arbitrary values, and before definite results can be obtained, there are a number of coefficients to be applied; therefore it cannot be extensively employed in its present form.

Mr. Strachan. I think meteorologists should give some attention to the duration of solar radiation; hitherto they have been content to observe merely its intensity. It does not seem very difficult to arrange the solar thermometer to register photographically, aided by a small spring clock. At least hourly observations of the solar thermometer should be taken at the well-equipped observatories between

the hours of, say, 9 A.M. and 3 P.M. in winter, and more frequently in summer. A few years' series of such observations would, no doubt, be instructive, and might indicate other methods of investigating the sun's heating effect in the different months and under varying atmospheric conditions.

Mr. CASELLA. There are five convenient means of taking observations on solar heat, viz.:—1. The black bulb *in vacuo*, which has been so carefully tested by the Rev. F. W. Stow. 2. Pouillet's pyrheliometer, described by Dr. Tyndall, which otherwise, to my mind, has not received the attention its merits seem to deserve. 3. The ordinary black-bulb thermometer. 4. An arrangement by Padre Secchi, consisting of three thermometers, two of which are contained in a water-jacket, of varying temperature, whilst the third is exposed to the direct rays of the sun. 5. Another arrangement by Mr. Southall, called the heliopyrometer, in which a black-bulb maximum thermometer is placed in a black box lined with black cloth and covered with plate glass; this being exposed to the sun's rays, about noon, even in this climate, will rise to an average height of say 228°, and I have seen it rise as high as 231°·5.

Mr. STRACHAN. As regards Secchi's instrument, Mr. Ericcson, in 'Nature,' has shown it to be useless.

The PRESIDENT. We appear to be more agreed as to the mode by which observations should be made than we are as to what instruments can be relied upon. There appears to be a strong feeling with some that thermometers in jackets can be trusted to a certain extent, whilst others object to them entirely.

The PRESIDENT. The next question is No. 18 of the Report of the Leipzig Conference—"Can uniform times of Observation be introduced for the Normal Observations?" This is a most important matter, and one on which the Conference allowed a long discussion. M. Bruhns proposed that as opinions were so very much divided at present, it would be better to postpone this question till the Meteorological Congress next year, and threw out for consideration whether or not it would be advisable to introduce generally the astronomical division of time, in order to bring the continental observations into harmony with the English.

Mr. SCOTT. The difficulty in proposing uniformity in hours of observation is that the hours differ in different countries; for instance, Prof. Wolf says that if in Switzerland a change of hours were proposed almost all observers would cease to observe. In this country, if certain hours are to be observed, then, I think, 9 A.M. and 9 P.M. are the most likely to suit the convenience of observers; but in the North-German system, established by Dove, we find that they call for 6 A.M., 2 P.M., and 10 P.M. for observations. In this country we should find these hours difficult, and we must only conduct observations at a time when observers can do so most conveniently to themselves; and I hope it is a question which will come before the Council, and whatever hours are recommended to them, I hope they will adhere to. On the question of hours there was a long discussion at the first Meteorological conference, at the Cambridge meeting of the British Association, in 1845, and from that discussion our self-recording system of registration, which is independent of hours, took its rise.

Dr. MANN. There are some reasons for assuming 9 A.M., 3 P.M., and 9 P.M. to be a good series of hours for recording observations, as they are certainly convenient ones. In one carefully worked-out comparison with observations in Natal, I found that I deduced identically the same yearly mean temperature from a year's series of observations taken daily at these hours, and from the means of daily records of maxima and minima self-registering instruments.

Mr. WHIPPLE. Of course self-recording instruments are much to be desired; and having these established at certain points, I say let observers choose their own hours, within defined limits, and then you will get more observations. We shall, I have no doubt, be soon able to make tables of daily range suitable to most localities. I have no doubt that, for barometer use at least, we shall be able to treat observations in the way I have suggested by tables. Temperature observations may cause more difficulty.

Rev. F. W. STOW. I have just put down a few figures which show the advantage of taking observations at 9 A.M. and 9 P.M., or 8 A.M. and 8 P.M. I have extracted from the results of observations made at Brussels for 20 years, the corrections to be applied to the mean of the daily maxima and minima in order to obtain the true mean temperature. I then took out from Glaisher's tables the corresponding corrections for the mean of two observations at 9 A.M. and 9 P.M., and also those for observations at 8 A.M. and 8 P.M., the one series of corrections being −, the other +.

From the following Table it will be seen that by combining the registered extremes with the temperatures observed at 9 A.M. and 9 P.M., or 8 A.M. and 8 P.M., you approach very near to a true mean. In fact you have, roughly speaking, four observations daily, at intervals of six hours.

UNIFORMITY IN HOURS OF OBSERVATION.

Month.	Corrections for mean of daily max. and min. (1)	Corrections for mean of observations at 9 A.M. and 9 P.M. (2)	Corrections for mean of observations at 8 A.M. and 8 P.M. (3)	Corrections for mean of (1) combined with (2).	Corrections for mean of (1) combined with (3).
January....	− 0°·4	+ 0°·7	+ 0°·8	+ 0°·15	+ 0°·20
February ..	− 0·7	+ 0·9	+ 1·1	+ 0·10	+ 0·20
March	− 0·8	+ 0·9	+ 1·7	+ 0·05	+ 0·45
April	− 1·0	+ 0·5	+ 1·3	− 0·25	+ 0·15
May	− 0·8	+ 0·2	+ 0·7	− 0·30	− 0·05
June	− 0·8	− 0·4	+ 0·1	− 0·60	− 0·35
July	− 0·7	0·0	+ 0·3	− 0·35	− 0·20
August	− 0·9	+ 0·4	+ 1·0	− 0·25	+ 0·05
September..	− 0·9	+ 0·7	+ 1·5	− 0·10	+ 0·30
October	− 1·0	+ 0·7	+ 1·2	− 0·15	+ 0·10
November ..	− 0·8	+ 0·7	+ 0·8	− 0·05	0·00
December ..	− 0·5	+ 0·6	+ 0·7	+ 0·05	+ 0·10
Year	− 0·8	+ 0·54	+ 0·93	− 0·14	+ 0·08

Mr. SYMONS. I should like just to say that I differ from Mr. Whipple as to the latitude he would allow to observers. I cannot anticipate self-recording apparatus will be applied generally throughout the country; therefore we must depend on eye-observations; and if observers will not take observations with some little self-denial, we had better be without their observations. So, also, with respect to observations of extraordinary phenomena; observers whose interest in the subject is insufficient to induce them to take extra observations of unusual phenomena without special instructions, are not the class of observers I should wish to encourage. Dr. Mann referred to observations at 9 A.M., 3 P.M., and 9 P.M.; no doubt every additional hour given to the subject is an additional approach to that continuity which we seek; but there is this disadvantage in adding a 3 P.M. observation, that it would destroy the advantage possessed by homonymous hours and mentioned by Mr. Stow. I think, also, it should be decided whether observations are to be taken according to Greenwich time or local time. If we have 9 A.M. local time, the observations will not be simultaneous; and if, on the other hand, we have Greenwich time, we have different points in the daily curves.

Mr. WHIPPLE. I would ask, is it desirable that observers should be told that if they cannot fall in with our views, and take their observations at a given hour, that their observations must be refused? My opinion would be, rather accept the observations at whatever time the observer can make them.

The PRESIDENT. The time we have given to this subject is short, especially considering its importance. One of the points started is, whether we should be guided by local or Greenwich time, and I do not see how we can properly take the whole matter into consideration with the limited time at our command; I think, therefore, we should determine whether or not, as this matter has been so imperfectly discussed, we should reopen the matter at our next meeting, so that our English meteorologists should be better represented at the Congress. I wish for a fuller expression of opinion upon a larger number of points. Is it your wish that this should stand over to the next meeting for considering the desirability of uniformity in the hours of observations? and, if so, what hours?

The PRESIDENT said that the next question, No. 20 of the Report of the Leipzig Conference, was:—

"What are the Rules and what the Intervals of Time for which the Means of the several Meteorological Elements should be calculated? Which is the better plan, to begin the Meteorological year with December or with January?"

The following letter was read :—

"Litherland Park, near Liverpool,
"14th April, 1873.

"WILLIAM MARRIOTT, Esq.,
"Meteorological Society, London.
"DEAR SIR,

"I am much flattered by your invitation to attend the meeting of your Society which is to be held on Wednesday next, and regret that I shall not be in London at the time. I wish, however, if in accordance with your regulations, to submit to the meeting the following remarks on one of the topics which have been proposed for discussion.

"In taking the means of long, or comparatively long, periods, whether these be groups of daily, monthly, or yearly observations, it seems to be of little importance at what point the series commences, A.M. or P.M., the beginning or the middle of the month, the 1st of January or the 1st of December, whether we commence with maximum or minimum values; but, in taking the mean for a single day or year, or for two or three days or years, it becomes necessary to be more careful. In such cases it is scarcely consistent to commence with a point near either a maximum or a minimum. For example, in thus taking the mean temperature for a daily interval, we are open to the inconsistency of joining the half of one day or of one night with the complementary half of the next day or the next night. If we commence with civil time, we join the halves of two separate nights. If we commence with astronomical time, we join the halves of two distinct days. If, for the yearly period, we begin with midwinter, we join the halves of two distinct winter seasons. In such cases it would evidently be better not to commence with a known maximum or minimum.

"When a number of days or a number of years are grouped, so as to obtain mean values, this objection is of less moment.

"As the month is altogether an artificial division, the beginning or end of a particular month should not, I think, be allowed to interfere with the grouping of what may be termed natural meteorological periods or seasons. On this account I wish to make objection to the suggested division of the year into periods of three months each, whether beginning with 1st of January, as proposed by some meteorologists, or with the 1st of December, as proposed by others. I admit, however, that the latter date corresponds more nearly with the beginning of a natural or seasonal period than the 1st of January. In this matter we should, I think, be guided, to a great extent, by the position and relative motion of the sun, the acknowledged source of all climatic change. The movement of the sun in declination is so rapid at the equinoxes as compared with the solstices, and this comparatively rapid movement lasts so short a time as compared with the whole year, that I would propose two months each for the two equinoctial seasons, and four months each for the summer and the winter seasons. My attention has been specially drawn to this subject while making an examination of the winds of Liverpool. Here I found that such a division of the year gave more consistent results than the division into equal periods of three months each. An examination of curves of mean annual temperature for different places will also show that this division is suitable for seasonal means of the other meteorological elements. Temperature is usually taken as the leading meteorological element; and if temperature is to guide us here, it will be seen that the most rapid change occurs during two months near the times of the equinoxes.

"I say near the time of the equinoxes, because the cumulative effects, whether of increase or decrease of temperature, move the periods of most rapid change to some time after the 21st March and the 21st September. I have found the two months March and April, and the two months September and October, give very good results; but the periods of two months lying between the middle of March and the middle of May, and between the middle of September and the middle of November, may possibly be better, as corresponding more exactly with the more rapid changes of temperature at our own stations. Either of these equinoctial seasons, of two months each, will, I think, be found on examination to be preferable to seasons of equal periods of three months each.

"One word now on the artificial divisions of the year. Modern investigation leads to the conclusion that the automatic records of the usual meteorological elements should be tabulated for hourly intervals; and various reasons may be urged for dividing the year into the same number of parts, *i. e.* into twenty-four instead of into twelve parts, and that these should be made as nearly equal to each other as

the number of days in a year will permit. I will not now attempt to indicate these divisions in detail, neither do I wish to indirectly support the idea of a fortnightly or semilunar period. It must be plain, however, to those who have applied Bessel's formula to the investigation of meteorological phenomena, that a duodecantal term exists which deserves attention—that is, a term which has twelve maxima and twelve minima in each year. Now this term cannot be obtained so easily in any other way as from semi-monthly averages. In taking monthly means we cancel out all its features, we destroy all trace of it.

"It must not be said that periods of about fifteen days are too short to show any very distinctive features, as means of shorter periods sometimes show very decided differences, even at those seasons of the year when change is slowest. As an example, take the Kew temperatures for the month of July 1869, which month I happen to have divided into three periods, for another purpose, of 10, 10, and 11 days respectively. The following shows the result:—

	1st period. July 1 to 10 inclusive.	2nd period. July 11 to 20 inclusive.	3rd period. July 21 to 31 inclusive.
Mean temperature from hourly observations	$61^\circ 74$	$66^\circ 50$	$64^\circ 35$
Coefficient for polar change, or one half of the daily range	7·31	8·64	8·31
Coefficient for quadrantal change, or one half of the semidiurnal range	·45	·74	·56
Coefficient for sextantal change, or one half of the 8-hourly range	·42	·64	·65

"Changes so great as these may sometimes occur in even shorter periods, it may be even in consecutive days; but they become more important when they affect the means of so many as 10 days, as in this example. All that is contended for is, that by taking half-monthly instead of monthly periods as at present (that is, by adopting twenty-four instead of twelve artificial periods) we shall get a more complete idea of the changes which really occur; that by adopting these divisions we shall, without giving this generation more trouble, be putting our materials into a shape which will be more useful to those who follow us.

"This is not, however, the time to dilate on this topic; and I will only add that, while regretting that so few meteorologists follow up this branch of our science, I congratulate this Society and meteorologists generally that the Committee of Management and officers of our National Meteorological Office are taking so much interest in this as well as the other interesting topics which are to engage your attention at the coming meeting.

"I am, dear Sir,
"Yours very obediently,
"W. W. RUNDELL.

"*Note.*—I append fuller details of the Kew observations for July 1869, alluded to above.

1st group. July 1-10.
$$T_x = 61^\circ{\cdot}74 - 6^\circ{\cdot}20 \cos\frac{360^\circ x}{k} - 3{\cdot}87 \sin\frac{360^\circ x}{k} + {\cdot}15 \cos 2\frac{360^\circ x}{k} + {\cdot}42 \sin 2\frac{360^\circ x}{k} + {\cdot}405 \cos 3\frac{360^\circ x}{k} - {\cdot}095 \sin 3\frac{360^\circ x}{k} \text{ \&c.}$$

2nd group. July 11-20.
$$T_x = 66^\circ{\cdot}495 - 7^\circ{\cdot}00 \cos\frac{360^\circ x}{k} - 5{\cdot}07 \sin\frac{360^\circ x}{k} + {\cdot}380 \cos 2\frac{360^\circ x}{k} + {\cdot}629 \sin 2\frac{360^\circ x}{k} + {\cdot}688 \cos 3\frac{360^\circ x}{k} + {\cdot}100 \sin 3\frac{360^\circ x}{k}, \text{ \&c.}$$

3rd group. July 21-31.
$$T_x = 64^\circ{\cdot}345 - 7^\circ{\cdot}163 \cos\frac{360^\circ x}{k} - {\cdot}422 \sin\frac{360^\circ x}{k} + {\cdot}441 \cos 2\frac{360^\circ x}{k} - {\cdot}342 \sin 2\frac{360^\circ x}{k} + {\cdot}641 \cos 3\frac{360^\circ x}{k} - {\cdot}126 \sin 3\frac{360^\circ x}{k}, \text{ \&c.}$$

"Here T represents the temperature at the hour x (in these examples 1 A.M.). The terms on the other side of the equation show in detail the coefficients for that hour. k in this case represents twenty-four hours. "W. W. R."

Mr. Scott said Mr. Rundell had paid a great deal of attention to the subject. If you take half months, the use of Bessel's Interpolation Equations is simple, and you have the advantage of 24 periods in the year and 24 hours in the day. The question before us is, "How to divide the year into periods?" It does not so much matter what the period is, so long as we are all agreed upon it. Supposing you take the five-day mean, that would give 73 periods in the year. I think we want something shorter, and good will be done if the Meteorological Congress at Vienna can agree as to what periods should be adopted.

Mr. Dines. What few remarks I have to make refer to rainfall only. The months are a very convenient division, and one we have got used to; but I think a much shorter time (say 5 days) would be preferable. February and March are our driest months, September and October the wettest; but the rainfall differs very much in different parts of the same month.

Mr. Scott. The division of the year into 73 parts gives us a troublesome number to deal with; and therefore it has been suggested by Prof. Buys Ballot that by making 5 of the five-day periods into six-day periods, you by this means get 72 periods, and then you can get 12 or 24 periods. As regards the giving up of the civil year, it will be seen by a very interesting paper by Mr. A. F. Osler, F.R.S., in the Report of the British Association for 1865, that there are indications that the prevalence of certain winds follows periods which are independent of the civil year altogether.

Mr. Dines. What I meant by my observation was this, that the rainfall during the second week in September and October differs as much from that in the fourth week as the rainfall of February and March differs from that of September and October, and therefore a shorter division of time would be preferable.

Mr. Strachan. Mr. Rundell's paper has been quite a surprise to me; and if it should be corroborated that the curve of atmospheric pressure exhibits the numerous maxima and minima during the year detected by him from his examination of the bi-monthly values for Liverpool, he will have made an important discovery. It certainly seems to me that bi-monthly values for the meteorological means could be more readily and accurately dealt with by Bessel's formula than the large number (73) of five-day means which the computer has to manage. But this question must be settled by the heads of Institutions and Observatories, and probably in no other department of meteorology would they do a greater service than by agreeing to a uniformity of practice in the publication of means.

Mr. Whipple. With respect to this question I think the English opinion would be decidedly averse to adopting 5-day periods, because Sunday, upon which day many observations are omitted, would cause an inequality in the means; to telegraph observations especially 5-day periods would be unfair indeed. I think we must do away with monthly periods, and that, presuming the existence of atmospheric tides, every advantage would be gained by dividing the year into lunations. Then why not have lunations, and treat subdivisions accordingly? As regards the time of terminating the day, I think it had better remain as it is.

Mr. Symons. In respect to the termination of the year, the strongest argument for closing with the civil year is, that Prof. Buys Ballot, all whose publications have closed with November, has expressed his willingness to conform to the civil year: such an expression coming from him is worthy of weight. The relation between meteorology and civil life is great, and meteorologists should do what they can to conform to the customs of civil life. I am afraid that meteorologists will have some difficulty in inducing the public to take up with changed quarters of the year; and until they can do so, I think it undesirable to change.

The President. I must also say of this subject, that we find it too important to be disposed of in so short a time. I think, with Mr. Symons, that the meteorological and civil year should agree. If you make any alteration, you will raise fresh difficulties, and had better therefore not disturb present arrangements in England. At least that is my opinion.

The President. The next subject, "Regulations to be adopted for carrying out the recommendations of a Congress," there is no time left to discuss; therefore we must adjourn this meeting till the meeting in May, when I hope the latter subjects will receive the full attention they deserve.

The Meeting was then adjourned.

MAY 21st, 1873.

Ordinary Meeting.

JOHN W. TRIPE, M.D., President, in the Chair.

HENRY COLBORNE, 53 Tachbrook Street, S.W.; Rev. HENRY FFOLKES, Hillington Rectory, Norfolk; and EDWIN EDSALL GLYDE, 3 Church Road, Dartmouth Park, Forest Hill, S.E., were balloted for and duly elected Fellows of the Society.

The names of four Candidates for Admission into the Society were read.

The PRESIDENT. The first business for this evening is to resume the discussion on Question No. 18, from the Report of the Leipzig Conference—"Can uniform times of Observation be introduced for the Normal Observations?"

Mr. GLAISHER. In respect to the times at which Observations should be taken, as to whether astronomical or ordinary mean time, I think for every thing in connexion with astronomy astronomical time should be used, and every thing in respect to meteorology ordinary mean time should be adopted; and I say this as based upon long experience. With respect to uniformity, no doubt it would be a great thing if all observations could be taken at one instant; but if observers be limited to a certain definite time, it seems to me you would have very limited observations. My impression is, that observations should be taken at times most convenient to the observers; and if this latitude be allowed, you will have a series of observations with regularity, and continued from year to year.

Mr. SYMONS. There is one other point on which I shall be glad to hear Mr. Glaisher's opinion; and that is, the question of whether local or railway time should be adopted. I know that at a great many stations the difference between the two is not very sensible; but at some English stations we have a difference of 20 minutes, and I think we should come to a decision at once on this question. If we are at the same point of the daily temperature curve, then observations are not taken synchronously throughout the country. I do not profess to be able to give a competent decision myself on this point. I do not know that this subject has been brought to the attention of observers; for, so far as my experience goes, there is a considerable diversity of practice. I need hardly say that it is desirable to call their attention to this, so that uniformity of practice may be ensured.

Mr. SALMON. In connexion with the remarks of the last speaker, I think the locality of Ireland should be taken into consideration. When we compare the observations taken in England with those from the west side of Ireland, there is a material difference between them in local time. In England, railway time or Greenwich time is kept; but in Ireland, Dublin time is used.

Dr. MANN. There is one course which it strikes me might work advantageously—namely, to establish a fixed time for observations, and to consider all observations which are made at the adopted regulation hour of the day as having a higher value than those which are made *ad libitum* at other times.

Mr. BICKNELL. With reference to what has fallen from previous speakers on the advantages of taking observations by Greenwich time, I am of opinion that the adoption of a fixed time, especially in the west of Ireland, where the difference is nearly half an hour, would limit observations greatly.

Mr. STRACHAN. The decision on this question should depend upon what normal observations are. If only such observations as are taken at equidistant parts of the day be meant, then local time might well be adopted. Few amateurs can take more than one set of observations daily, but all of course wish their labour to have some practical value. The observations of amateurs are, in fact, useful for climatic deductions, and as data for studying synchronous weather. For the former purpose a definite local hour might advantageously be fixed upon; for the latter, observers must conform to Greenwich time.

Mr. SCOTT. There is an obstacle in the way of our having uniform times for observation, because we are so dependent on unpaid assistance. In other countries they say to their observers, "If you will not observe at our hour you shall not have your observations published;" and the question for this Society is, whether or not they shall recommend to their observers to try and make their observations at the same hours by Greenwich time: persons who really are interested in their work will take the trouble to get the exact time. With reference to daily weather-charts, it is necessary that observations should be synchronous. The difference in

observations in these islands is not great; but when you come to the observations made in the New-England States, which are made at the same second of time with observations made in California and San Francisco, the difference between local and Washington time is great. Each country must work for itself. I think it important, notwithstanding, that this Council should decide whether or not they would recommend a certain time (say 9 A.M and 9 P.M.) for ordinary observations.

Mr. SOPWITH. I quite agree in thinking that observers who take correct observations would adopt a certain time, if recommended to them to do so, and I think that in Great Britain Greenwich time might be considered a general time. With respect to atmospheric observations, I have always thought that they should be taken at equal periods of time; but I have found 9 A.M., 3 P.M., and 9 P.M., having two intervals of 6 hours and one of 12 hours, practically convenient.

Mr. BREWIN. I think it would make no difference to maximum and minimum; but if you come to take the mean temperature at a fixed hour it would make a good deal of difference, and for these observations I think it better to have local time.

Mr. SYMONS. Inasmuch as railway time is generally known throughout the country, local time is, for civil purposes, practically extinct; but some observers have resuscitated it for their daily observations. With reference to the hours 9 A.M., 3 P.M., and 9 P.M., I should prefer 9 A.M. and 9 P.M. My reason for objecting to 3 P.M. is, that whereas the average of 9 A.M. and 9 P.M. is very nearly the mean temperature of the day, if you interpolate 3 P.M., which is much higher, you then obtain a value which is not the mean temperature, and you are hardly any the better off. I quite recognize the advisability of shortening the intervals, and making them 9 A.M., 3 P.M., 9 P.M., and 3 A.M.; but this is out of the question.

Mr. SCOTT. Similar remarks about the 3 P.M. readings have been made by Prof. Buys Ballot, that any mean obtained from combinations of observations in which day observations are predominant is fallacious. You can divide the day into three 8-hour periods, but you cannot have one period of 12 hours and two of 6.

The PRESIDENT. I think the general opinion, as elicited by this discussion, is, that the two periods of 9 A.M. and 9 P.M. would be better than the three periods of 9 A.M., 3 P.M., and 9 P.M. I agree in thinking that the 3 P.M. would represent, to a great extent, the maximum observation, and 3 in the morning would show the coldest. Therefore the 9 A.M. and 9 P.M. observations may be regarded as intermediate between the maximum and minimum respectively. With regard to time, I think it important that local time should be observed and not Greenwich mean time, and that therefore we should take our observations so as to obtain as far as possible a record of temperature at such hours as would give a relative uniformity of solar elevation above the horizon. As Mr. Bicknell intimated, half an hour would make a great difference in temperature observations. There can be no doubt that statistics should be based on comparable data, and that therefore uniformity of time should be fixed. I should like to take the opinion of the meeting as to the hours 9 A.M. and 9 P.M. as against 9 A.M., 3 P.M., and 9 P.M., or the three 8-hour periods, or the four 6-hour periods, or any other you may recommend for adoption by observers; of course we cannot *insist* upon these hours.

The division was then taken, viz.:—

For 9 A.M. and 9 P.M. hours of observation	20 ayes.
„ 9 A.M., 3 P.M., and 9 P.M. „ „	0 „
„ any other hours of observation	0 „

The President declared the opinion for the hours of 9 A.M. and 9 P.M. to be unanimously agreed to.

The PRESIDENT. I shall now put the question whether we shall adopt local time; or Greenwich mean time for England, and Dublin mean time for Ireland.

Fourteen ayes were given for "local time;" and this number being a majority of those present, "local time" was declared to be carried.

The PRESIDENT. The next subject for consideration is "No. 20, Division of the Year for the Calculation of Mean Results."

Mr. SCOTT. I take this as two questions—first, whether to begin the year with January, and, second, whether we would adopt 5-day means, and what 5-day means they should be. For instance, if you divide the year (365 days) by 5, you have 73 exactly, a very unmanageable number. January, February, March, and April make exactly 120 days; and if you divide that into 5-day periods, you have an even number; but in the 4 months May to August you have 123 days, and in the 4 months September to December you have 122 days; and the question is whether

you should have one 6-day period for 5 of the 12 months, viz. May, July, August, October, and December, so as to divide the year into 72 periods. This is the plan that M. Buys Ballot has adopted, and has found to work very well. Then there is the question whether we should begin the meteorological year with December, or, according to the Civil Calendar, with January. The question of 5-day means was fully discussed at Leipzig, and we could not come to a definite decision upon it.

The PRESIDENT. I may say that I think meteorology should be identified with civil matters as far as possible.

Dr. MANN wished to have the further information from Mr. Scott, whether he was to understand there were to be five 5-day and one 6-day periods in each 31-day month, under the proposed system.

Mr. SCOTT. Five-day periods in each month, but the sixth period in some of the months to be of six days. This would agree as nearly as may be with the ordinary civil months.

Mr. STRACHAN. The character of the observations to be dealt with should have been stated. We must start with daily values. Temperature, for instance, has a daily curve, having one maximum and one minimum; but one observation daily is not sufficient for its mean value. From proper daily means only can correct monthly means be deduced. Objection is made to monthly means, because the months vary in length from 28 to 31 days. One or two days make no sensible difference on such means. Still, if it be objected that 28 days are insufficient, give "weights" to the observations, and calculate the probable error on 28 compared with 31. You will find this a nice little bit of labour, scarcely warranted by the result. Knowing this, I am content with monthly means: these show an annual curve for temperature with one maximum and one minimum. However, the diurnal and annual curves for the other meteorological elements are not analogous to those for temperature. The diurnal curve for the barometer has a double maximum and minimum; and the annual curve is abnormal, and, indeed, so uncertain, that computers have been led to subdivide the months. Those who have computed it from bi-monthly means get quite a different curve to that deduced from monthly means. If we employ 5-day means, we modify the curve still more, while we enormously increase the labour of computation. The preference for monthly, bi-monthly, or 5-day means should not be pronounced without considering weekly means. There is a great deal to be said in favour of 7-day means, especially in connexion with the Registrar-General's returns of mortality.

Mr. DINES. I made some observations at our last Meeting respecting the difference of rainfall in different parts of the same month, but had not then the figures with me. I have them now. Speaking relatively only, the rainfall for 47 years has been as follows in September and October:—

2nd week in September	·160 inch.
4th week in September	·257 „
2nd week in October	·162 „
4th week in October	·279 „

I do not think the monthly division would give a good idea of the distribution of the rainfall, but that we should have shorter periods.

Mr. SALMON. I do not think we should ignore the connexion which meteorology has with civil life; therefore it is necessary that we should come to monthly means; then, by a combination of those means, we get the seasonal means. A great deal as regards health is connected with seasonal means; therefore I think we should have seasonal means, beginning with

December to February	90 days.
March to May	92 „
June to August	92 „
September to November	91 „

Whatever we may do in respect to 5-day periods, we should do wrong if we ignore monthly means and seasonal means.

Mr. SYMONS. There is no question but that meteorology and civil life are so closely connected, that it is quite right we should conform to the usage of civil life. There is one point which I wish to draw attention to, and that is with respect to seasonal means. I think the arrangement of beginning the meteorological year with

December is a good one; but we must take care that we do not follow the example of some of the foreign meteorologists, of beginning the annual statement with 1st of December. I believe the better plan for this, and which has been adopted in Russia and France, is beginning it with the civil year, but giving the "meteorological year," *i. e.* December to November, also.

Mr. Scott. The proposal for beginning the year with December has been given up at Leipzig as being too troublesome. Prof. Dove has professed his readiness to abandon it, and take the civil year for publications.

Mr. Sopwith. The several points now in discussion require much careful consideration—much more than can be given in the course of a conversation like the present. If the opinion of this Society is to be of any weight at any future Conference, I think it would be a great advantage to form a Committee to draw up a series of questions and statements on all matters in connexion herewith, numbering the questions, and requesting in reply the attention of observers to all or any of the subjects. A collateral advantage to be gained by adopting a course like this would be the obtaining much valuable information given with care; and this would tend more to the credit of our Society than allowing the vote of a comparatively small meeting like the present to be considered as representing the decision of the Society.

The President. I think Mr. Sopwith's suggestion extremely valuable, and will put it to the Meeting. The discussion has been as to periods, whether of 5 days or 7 days, or whether 5-day periods should be interpolated with a sixth day, in such a manner so as to divide the year into 72 periods. The monthly means are objectionable, because they do not represent an even number of days. At the Leipzig Conference, the proposition to commence the year with December was given up. I myself have been in the habit of making my own seasonal tables, commencing with December. Mr. Sopwith's suggestion is valuable, if you determine to circulate this Report:—"That a Committee be appointed to draw up a statement of questions on all matters connected with this subject, and the same be sent to the Fellows, requesting their reply." If you acquiesce in this course, I will put it to you as a motion.

This was unanimously agreed to by the Meeting, and the matter was entrusted to the Committee of the Council appointed to prepare a form for recording observations, with the addition of Mr. Sopwith's name.

The consideration of Question No. 26 was postponed.

The following papers were then read:—

"On Land and Sea Breezes." By John Knox Laughton, M.A., F.R.A.S. (p. 203).
"On Land and Sea Breezes." By Rev. Fenwick W. Stow, M.A. (p. 208).

Mr. Salmon. There is one important point in connexion with the subject of land and sea breezes, and that is the geographical position of the land. Geographical books say, breezes from the sea in daytime, and from the land during night; but I have been looking over some registers on Africa, and I find very few land breezes recorded; in fact the wind is generally S.E. to W.S.W. Differences of temperature are influenced by vegetation.

Mr. Strachan. This evening we have had a new theory of land and sea breezes, and whatever opinion we may entertain of Mr. Laughton's paper, we must all confess that he has put it forward with great ability: but the theory should be supported by observations; for we cannot suppose that observers have been so completely in the wrong for so many years past. Mr. Laughton's paper, however, will do good in calling attention to the subject.

Mr. Lecky. Mr. Laughton's remarks on the land and sea breezes being felt so strongly on a north-eastern coast in these islands are very interesting. They, or at least the sea breeze, are constant in summer on our south coast: I can speak as to Cork harbour and river, where the latter blows very strongly during the day, but dies down in the evening. I am not so sure as to the land breeze in this locality. I believe both are very much influenced by a hilly or mountainous country, and that they are very light where the country is flat.

Mr. Scott. With regard to Queenstown and what Mr. Lecky has said, the wind there is remarkable. The breeze seems to me to depend on the tide. From observations I myself have made, I have found that a wind always freshened against the tide.

Mr. Lecky. I do not think the tide in Cork harbour has any effect on the wind.

Mr. Laughton. I would entirely agree with Mr. Lecky that the strength of

the breezes depends more on the contour of the land than on the nature of the soil. Of course I do not expect the theory I have put forward to be received without full inquiry; to this I believe it is entitled. But what I principally wanted was to call attention to the subject; and I have attempted to do so by what many of you may perhaps consider a very radical paper.

"Notes on a Double Rainbow observed at Kirkwall." By Robert H. Scott, M.A., F.R.S.

Mr. R. H. Scott exhibited to the Society a sketch of a double rainbow which had been observed by Mrs. E. Mitchell, Glaitness House, Kirkwall, on the 13th of November, 1871. He stated that he had first heard of the phenomenon through Dr. Clouston, and that on his visit to Kirkwall last summer he had called on Dr. Mitchell and obtained a copy of the sketch made by Mrs. Mitchell when she noticed the bows.

They were placed side by side, and he (Mr. Scott) was at first inclined to consider that the phenomenon had been probably due to the existence of a parhelion, similarly to the suggestion of Dr. von Littrow (Journal Austrian Met. Soc. vol. vii. p. 286) as to the probable cause of the double rainbow observed at Vienna, July 3rd, 1872.

Dr. Mitchell, in a subsequent letter, says:—"The double rainbow was visible only for a few minutes, and the portions seen distinctly not large. The colours bright in both. We see now and then double rainbows of the usual form, with a faint reflection forming a third limb; but the real double bow had all the colours reversed, or back to back. There was something peculiar in the atmosphere on that morning. The bay had a peculiar glassy look, with a number of dark clouds and a few light ones floating quietly across the bay from west to east."

On the whole, he (Mr. Scott) was disposed to think that the phenomenon had been caused by a mirage.

Mr. Lecky. In allusion to Mr. Scott's account of a double rainbow, I saw such, or rather a triple one, at Valencia, co. Kerry. It was about 10 o'clock in the morning, in the month of April. I was standing on the quay, in front of my residence; the sun was bright in the south-east, a heavy shower, or skirt of rain, was falling to the north-west, and almost a perfect calm at the time: there was a bright and nearly perfect bow, with its accompanying secondary bow, the colours of course reversed, while between the two was an intermediate one, but with the colours in the same order as in the primary. This bow formed more than a semicircle, the springing of the arches of both it and the primary being identical; but the crowns were separated by several degrees. I was puzzled at first to account for so unusual a phenomenon, but soon found that the intermediate bow was produced by the reflection of the sun from the glassy water of the harbour, which stretched away for four miles to the south-east. I find, in the beautifully illustrated French work 'L'Atmosphère,' a similar case, at p. 195, fig. 69.

Mr. Symons. The triple form of rainbow is relatively common. It is figured in many works; but the form described by Mr. Scott I have never seen.

The President. I have seen a double rainbow, such as Mr. Scott has described.

The Meeting was then adjourned.

June 18th, 1873.

Annual General Meeting *.

John W. Tripe, M.D., President, in the Chair.

Mr. Pastorelli and Mr. Tabor were appointed scrutineers of the ballot for Officers and Council.

Mr. Symons read the Report of the Council *.

It was proposed by Mr. Bicknell, seconded by Mr. Harding, and Resolved:—"That the Report just read be received and adopted, and circulated among the Fellows of the Society."

The President then read his Address (p. 217).

* The Proceedings of the Ordinary Meeting in June will appear in the next Number of the Journal, with the Report of the Council.

It was proposed by Mr. CASELLA, seconded by Mr. FIELD, and Resolved:—"That the Thanks of the Society be given to the President for his Address, and that he be requested to allow it to be printed."

It was proposed by Mr. SCOTT, seconded by Capt. TOYNBEE, and Resolved:—"That the cordial and best Thanks of the Meteorological Society be communicated to the Council of the Institution of Civil Engineers for having granted the Society free permission to hold their meetings in the rooms of the Institution during the Session that has just ended."

It was proposed by the Rev. F. W. STOW, seconded by Mr. DYMOND, and Resolved:—"That the best Thanks of the Society be given to Dr. Tripe for his services as President during the past two years."

It was proposed by Mr. STRACHAN, seconded by Mr. LAUGHTON, and Resolved: —"That the Thanks of the Society be given to the Officers and other Members of the Council, and to the Auditors, for their services during the year."

It was proposed by Mr. LECKY, seconded by Mr. BIRT, and Resolved:—"That the Thanks of the Society be given to the Standing Committees, and that they be requested to continue to discharge their duties until the Council Meeting in October."

It was Resolved that Bye-Laws Nos. 15, 17, 34, and 39, as recommended by the Council, should be altered to read as follows:—"15. Each Fellow shall on his election pay the sum of One Pound for his admission fee; and if elected before the 1st of July, shall pay the sum of One Pound; and if elected after that date, shall pay the sum of Ten Shillings, as his contribution for the current year."

A long discussion took place with reference to the short notice upon which it was proposed to raise the composition fee; eventually Bye-Law 17 was proposed to read as follows:—"17. Any Fellow may, at his entrance, compound for his contributions by the payment of Twelve Pounds (exclusive of his admission fee); or he may, at any time afterwards (all sums then due being first paid), compound for his subsequent annual contributions by the like payment of Twelve Pounds." The alteration to take effect at once.

To this the following amendment was proposed by Mr. HARDING and seconded by Mr. CASELLA:—"That the Bye-Law be altered as proposed, but that it do not come into force, as regards existing Fellows of the Society, until January 1st, 1874."

This amendment having been put, was carried by a majority of 12 to 10.

It was then put as a substantive resolution, and carried by 21 to 1.

The following Resolutions were agreed to without alteration:—That Bye-Law 34 be altered to read as follows:—"34. At least six Ordinary Meetings of the Society shall be held in each Session, the Meetings to be held in the months of February, March, April, June, November, and December; the Meetings to be held on the third Wednesday in each month, or on such other day as shall from time to time be ordered by the Council. And the Council shall have power to call additional Ordinary Meetings at their discretion, or to increase the number of Ordinary Meetings in the Session."

That Bye-Law 39 be altered to read as follows:—"39. A General Meeting shall be held annually in the month of January, or on such other day and hour as shall from time to time be determined by the Council, to receive the Report of the Council on the state of the Society and to deliberate thereon; to discuss and determine such questions as may be proposed relative to the affairs of the Society; to elect the Officers and Council for the ensuing year; and to enact, alter, or repeal any of the Bye-Laws."

The retiring PRESIDENT then announced the result of the ballot, and declared the following gentlemen to be the Officers and Council for the ensuing year:—

President.

ROBERT JAMES MANN, M.D., F.R.A.S.

Vice-Presidents.

ARTHUR BREWIN, F.R.A.S.
GEORGE DINES.
HENRY STORKS EATON, M.A.
LIEUT.-COL. ALEXANDER STRANGE, F.R.S.

Treasurer.

Henry Perigal, F.R.A.S.

Trustees.

Sir Antonio Brady, F.G.S.
Stephen William Silver, F.R.G.S.

Secretaries.

George James Symons.
John W. Tripe, M.D.

Foreign Secretary.

Robert H. Scott, M.A., F.R.S., F.G.S.

Council.

Charles Brooke, M.A., F.R.S., F.R.C.S.
Charles O. F. Cator, M.A.
Rogers Field, B.A., Assoc. Inst. C.E.
Frederic Gaster.
James Glaisher, F.R.S.
John Knox Laughton, M.A., F.R.A.S.
William Carpenter Nash.
Thomas Sopwith, M.A., F.R.S., M. Inst. C.E.
Rev. Fenwick W. Stow, M.A.
Capt. Henry Toynbee, F.R.A.S.
Charles Vincent Walker, F.R.S.
E. O. Wildman Whitehouse, Assoc. Inst. C.E., F.R.A.S.

Dr. Tripe having left the Chair, it was taken by the newly elected President, Dr. Mann, who thanked the Society for the honour they had done him in electing him to that office.

The Meeting was then adjourned.

CORRESPONDENCE AND NOTES.

On the Aurora Borealis of April 1 and 2, 1873.
By William F. Denning, F.M.S.

On April 1 the phenomenon was first noticed at $8^h\ 49^m$, when an intense auroral glow pervaded the northern sky near the horizon, and gave a very similar effect to moonrise. At $8^h\ 51^m$ a streamer, about 1° broad, appeared, and shot up to an altitude of about 11°. This streamer was situated 2° northwards of β Cassiopeiæ, and was apparently connected with a faint auroral arch under Cassiopeia,

stretching from due N. to N.W. The stratus clouds in this part of the sky strongly reflected the aurora. This was very notably the case a little north of the bright star α Lyræ. The streamer disappeared at $8^h\ 56^m$; then there came into view an intense crimson glow in due N. and 10° above the horizon, but this also soon faded. At $9^h\ 3^m$ the auroral light became very evident under Cassiopeia, forming an arch from about N. to N.W. At $9^h\ 20^m$ there became perceptible another cloud of the aurora; but this, like the previous appearances, endured but for a brief interval, and afterwards there was no observed revival of the phenomenon.

On the following evening (April 2), however, another display of the aurora occurred. At $9^h\ 15^m$ several perpendicular streamers were seen on the N. side of, and below, Cassiopeia. These soon disappeared, but were succeeded by others in adjacent parts of the horizon. At $10^h\ 5^m$ two bright streamers were seen passing up to an altitude of about 20° on either side of the stars α and β Cassiopeiæ. The aurora changed its principal features very rapidly, but nothing remarkable was noticed. These displays were not exceptionally grand or brilliant, though at times very manifest and sufficiently marked to arrest the attention of casual observers. On April 4 an aurora was visible at Aberdeen, and the two displays I have briefly described were observed by many persons at different stations.

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XXVIII. *On some Results of Temperature Observations at Durham.* By JOHN J. PLUMMER. (Communicated by R. H. SCOTT, F.R.S.)

[Received May 6, 1873. Read June 18, 1873.]

FROM the beginning of the year 1850 a regular series of meteorological observations has been made at the Durham Observatory; and as very great care has always been taken to preserve the continuity of the record, some very interesting results may naturally be expected from the discussion of such a lengthened series. At present I shall confine my remarks exclusively to one or two points connected with the temperature observations, leaving any other results for a future communication.

In November 1867, when I was appointed to the office of Observer to the University, and had charge of these observations, I found that very little had been done to determine even the monthly means of the several elements, except during the first few years, in which the observations had been systematically reduced; and I resolved at once to make the whole of the series available for comparison. As regards temperature, however, a difficulty of a serious nature existed—namely, that during the first ten years the thermometers had been kept in a penthouse upon the north side of the Observatory, and during the remainder of the time upon a Glaisher's revolving stand. No observations had at any time been taken to ascertain the effect which the change of exposure and position would have upon the readings; but, fortunately, the old penthouse still remained untouched, and in its original position.

The penthouse, or, as it is usually designated, the "North Shed," consists of a large louvre-boarded enclosure, solidly protected from above, and open upon the south side, where the thermometers are sheltered by the north wall of the building. Upon the west side there is also a partial

protection from a projecting angle of the wall, but there is everywhere ample space for a free current of air. The thermometers are 3 feet 6 inches from the walls of the building, 17 feet above the ground, and 4 feet 6 inches above a balcony floored with lead, upon which, of course, the shed is erected. The position is thus fair, if not unexceptionable, and may perhaps be considered as representing tolerably well this system of exposure. The Glaisher-stand does not require such particular description. It is, I believe, in all respects similar to that used at Greenwich, the thermometers being about 4 feet 6 inches above the grass, and the situation in every way favourable.

To determine the mean differences of the thermometer-readings in these two positions was therefore my first care; and I early placed a maximum and a minimum thermometer in the old penthouse for this purpose. They have now been read simultaneously with those upon the Glaisher stand for nearly five years; and some reliance may therefore be placed upon a comparison of results. Of course, in a delicate inquiry of this nature, it was necessary to have the thermometers carefully and repeatedly compared with a reliable standard; and this has accordingly been done. The standard of the Durham Observatory is a well-made centigrade thermometer, with large elongated bulb, but without attached scale of any kind, the divisions being etched upon the glass stem. It is immaterial to the present inquiry whether its readings are exactly correct; that the several thermometers have been all reduced to this fixed standard by the application of appropriate index-corrections is all that is required; and this has been effected by the aid of three separate and independent comparisons.

I shall now give the mean differences of the monthly averages of maxima and minima temperatures for the five years (1868–1872) as found in the two positions.

TABLE I.

Months.	Average Difference of Maxima. Glaisher-stand —North Shed.	Average Difference of Minima. Glaisher-stand —North Shed.	Diff.	½ Sum.
	°	°	°	°
January	+0·77	−1·28	+2·05	−0·26
February	+1·22	−1·02	+2·24	+0·10
March	+2·39	−1·00	+3·39	+0·70
April	+3·18	−1·76	+4·94	+0·71
May	+3·95	−2·02	+5·97	+0·96
June	+4·90	−2·48	+7·38	+1·21
July	+5·38	−2·75	+8·13	+1·31
August	+5·03	−2·39	+7·42	+1·32
September	+3·22	−2·20	+5·42	+0·51
October	+2·05	−2·07	+4·12	−0·01
November	+1·08	−1·73	+2·81	−0·32
December	+0·58	−1·32	+1·90	−0·37
Mean	+2·80	−1·85	+4·65	+0·475

Column 1 gives the average excess of the reading of a maximum ther-

nometer for each month of the year when upon a Glaisher stand, over one in the North Shed. Column 2, the excess, or, more properly, since the sign is invariably —, the defect of the reading of a minimum thermometer similarly placed. The 3rd column, headed "Diff.," exhibits the excess of the mean daily range of temperature as found from the Glaisher stand over that found from the North-Shed thermometers, and is in itself a most distinct proof of the necessity of precisely similar exposure whenever observations from different places are to be compared, as well as evidence (were any wanted) of the desirability of an authoritative settlement of the vexed question regarding the proper form of thermometer-stand to be universally adopted. The column headed "½ Sum" shows the differences of monthly mean temperature of the air which would separately result from the two sets of observations if no correction were applied to the mean of the maxima and minima averages—a plan often adopted, and one which has the approval, I believe, of the Scottish Meteorological Society.

To determine such corrections, however, or to test the applicability of those furnished by Mr. Glaisher, is highly necessary whenever it is possible to do so; and as this can only be effected by a discussion of the readings of the dry-bulb thermometer at fixed hours, an inquiry into the eligibility or ineligibility of the use of Glaisher's tables of Diurnal Range formed the second question for consideration. It had been the custom at Durham to employ the Diurnal Range-tables, published in the 'Phil. Trans.' 1848, pt. i., where the corrections are not made to depend in any way upon the mean daily range of temperature; but no observations existed whereby to test their applicability to the latitude of Durham. To satisfy myself on this point I made, during four months, extra readings of the dry-bulb thermometer at hours widely distant from those of ordinary observation, and at a time of the day when the temperature was very much warmer. These I found gave very nearly the same results for the mean monthly temperature as those found from the usual observations—so nearly, indeed, that I discontinued the extra observations at the end of July 1868—a fact that is to be regretted, as, had they been continued at least throughout a whole year, a much greater reliance might have been placed upon the results of mean monthly temperature found from the dry-bulb thermometer. I have supplemented this want, however, by an investigation of the differences of mean monthly temperatures which each of the ordinary morning and evening readings of the dry-bulb yield when corrected for diurnal range, and have carried this investigation throughout the five years 1868–1872 inclusive. The following Table gives these average differences for each month.

TABLE II. Mean excess of corrected 10 A.M. Average Temperature over corrected 10 P.M. Average Temperature.

Months.	Mean Excess.
	°
January	+0·05
February	−0·12
March	−0·41
April	+0·11
May	+0·08
June	+0·67
July	+1·26
August	+1·22
September	−0·13
October	+0·38
November	−0·11
December	+0·25

This Table shows that for nine months of the year the results agree very closely, the mean difference being only $+0^{\circ}\cdot01$; but that for the three summer months the diurnal-range corrections are not quite large enough to satisfy the observations in this locality. Yet the mean temperature will by no means be greatly affected by this want of accuracy, certainly not to nearly the extent indicated in the Table, since the error must be divided between the two determinations, and will nearly disappear when the mean is taken. I have therefore assumed that for nine months of the year the corrections are *quite* trustworthy, and for the remaining three months are so nearly so that no sensible error will be thrown upon the mean temperature derived therefrom. As this result is as fortunate as it was unexpected, it may, perhaps, be right to suggest some circumstances which may partially account for it, more especially as Mr. Glaisher, in his tables of Diurnal Range (4th ed., London 1867), says that the numbers published in the 'Phil. Trans.' "have not been found sufficiently exact for observations made either near the sea or in parallels of latitude far from that of Greenwich." I believe the explanation will be found to depend upon the fact that the situations of the Greenwich and Durham Observatories present several remarkable points of similarity. Both stand upon the summit of a hill, and are distant from ¼ to ½ a mile from a river, to which the land slopes to the north and east, while, in all other directions, there stretches an extensive plateau. Durham is, further, about 10 miles from the eastern coast, and Greenwich a similar distance from the broad estuary of the Thames. The former Observatory, indeed, stands considerably higher than the latter; and this may possibly account for the diurnal range in the summer months being greater for Durham; but the resemblance of position in all respects but latitude is, I believe, noteworthy.

The dry-bulb thermometer having been similarly corrected to the Durham Standard, we are now in a position to determine the corrections to be applied to either set of maxima- and minima-means to deduce there-

from the true mean monthly temperature of the air. They are given in the annexed Table; and for comparison are added the similar corrections, given by Mr. Glaisher as satisfying the Greenwich observations.

TABLE III.

Months.	Corrections for Mean of North-Shed Max. and Min. Averages.	Corrections for Mean of Glaisher-stand Max. and Min. Averages.	Corrections for Greenwich, according to Mr. Glaisher.
	°	°	°
January	+0·34	+0·66	−0·2
February	+0·28	+0·21	−0·4
March	+0·01	−0·50	−1·0
April	−0·14	−0·80	−1·5
May	−0·34	−1·31	−1·7
June	−0·40	−1·61	−1·8
July	−0·32	−1·63	−1·9
August	+0·10	−1·22	−1·7
September	−0·32	−0·83	−1·3
October	−0·32	−0·31	−1·0
November	+0·17	+0·50	−0·4
December	+0·44	+0·81	0·0
Mean	−0·04	−0·50	−1·08

Depending, as these corrections do, upon only five years' observations, they cannot be considered definitive, especially as a slight doubt must remain upon the mean temperatures given by the dry-bulb thermometer; yet the accordance exhibited in each separate year emboldens me to put considerable weight upon the determination. The differences between columns 1 and 2 will, of course, give the 4th column of Table I.; and the reason why they do not do so precisely for the first four months of the year is, that the observations in the North Shed are defective for those months in 1868, and the first quarter of 1873 has been added to fill up the void. The principal fact elicited in this Table is, that the corrections to be applied to the mean of the maxima- and minima-averages to obtain the true mean temperature of the month are widely different for the two positions (though there is a general agreement as regards sign), and seem to depend entirely upon the degree and nature of the exposure. The 2nd column, it will be remarked, agrees fairly well with Mr. Glaisher's, except that the whole list, considered subtractively, is numerically less, and the variation or range of the correction for the summer and winter quarters is somewhat greater.

In conclusion, I would wish to express my opinion, gathered not only from the experiences herein detailed, but from the working of other stands, that the Glaisher revolving thermometer-stand is decidedly to be preferred to any other. Its principal defect consists in the thermometers not being sufficiently protected from the weather upon the side removed from the sun. If this were effected by a light louvre-boarding it is my opinion that the most desirable form of stand would be obtained. There

is no occasion to exaggerate the absolute necessity of a final settlement of this question; the numbers I have given show decisively the range of readings which may be obtained from thermometers situated in positions that would be held by most, if not all, meteorologists to be legitimate; and certainly more dissimilar conditions of exposure are in actual daily use by many observers. I regret only that I am unable to institute an inquiry into the differences arising from the use of all the recognized modes of protecting thermometers, as I believe much useful information would result from such researches, the position of Durham seeming eminently favourable for such observations, and that no satisfactory decision will be arrived at on this question till the experiment is actually made. I hope, however, what I have already done may awaken some interest in the matter.

The discussion on this paper will be found at p. 264.

XXIX. *Notes on the Connexion between Colliery Explosions and Weather in the Year* 1871. By Robert H. Scott, F.R.S., and W. Galloway, Inspector of Mines.

[Received June 17, 1873. Read June 18, 1873.]

The present paper is in continuation of one read by us before the Royal Society, April 18, 1872, and printed in the 'Proceedings,' vol xx. p. 292.

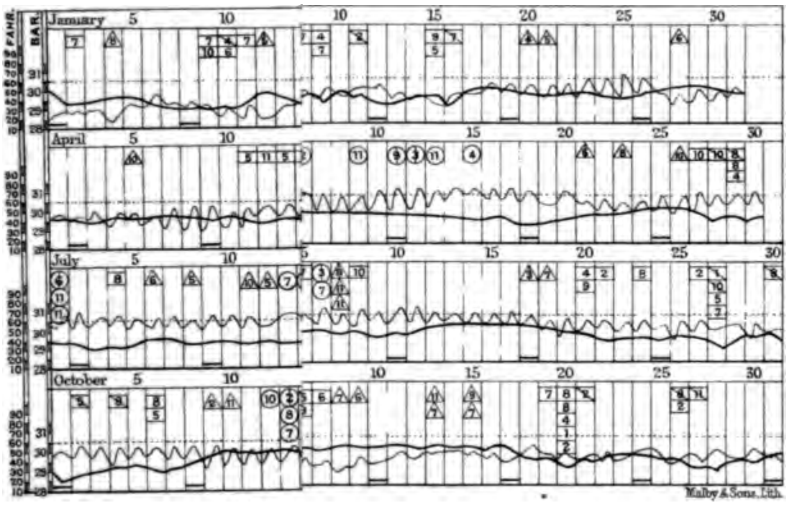
The curves of barometrical pressure and temperature for the year 1871 have been plotted from the continuous records of Stonyhurst Observatory. The dates of the fatal explosions are taken from the Inspector's Reports for the year. The dates of the non-fatal explosions have been obtained in part from the Inspectors themselves, in part through the kindness of Mr. R. S. Mitford, of the Home Office; the list of these occurrences, however, is incomplete, as we have been unable as yet to obtain information from two out of the twelve districts, viz. West Lancashire and North Wales and West of Scotland. For the purpose of comparison we have assumed the average of the three preceding years as the number assignable to the West-of-Scotland district, and the average of the other districts as that assignable to the West Lancashire and North Wales district.

We have made a rough estimate of the number of men injured by the non-fatal explosions of the six districts for which no numbers are given, by assuming the number of men injured by each explosion in the other six districts to be applicable also to them. All the *estimated* numbers are entered in brackets in the following list; but it would of course be far more satisfactory if the correct numbers and the dates of ALL REPORTED explosions were to be found in the Official Reports of the Inspectors.

1871.

ershire.

Cumberland.



Malby & Sons, Lith.

Districts.	Fatal.		Non-fatal.	
	Number of explosions.	Number of men killed.	Number of explosions.	Number of men injured.
South Durham	2	27	2	(3)
North and East Lancashire, or Manchester	3	3	19	26
West Lancashire and North Wales	6	84	(19)	(30)
Midland	5	42	6	6
North Staffordshire, Cheshire, and Shropshire	5	14	26	(41)
South-western	5	23	16	31
South Staffordshire and Worcestershire	4	4	27	(42)
South Wales	6	47	20	32
Northumberland, North Durham, and Cumberland	1	1	5	6
Yorkshire	8	10	17	(27)
East of Scotland	3	3	18	31
West of Scotland	4	10	(59)	(93)
	52	268	(234)	(368)

There are, further, 38 men reported to have been injured by the fatal explosions. In this manner we obtain a total of (286) explosions of fire-damp, by which 268 men were killed and (406) injured in the course of the year 1871.

There were five explosions, each of which involved the loss of more than ten lives; this exceeds the average number of the last twenty years, which is three.

Three explosions, involving the loss of fifty-eight lives, took place simultaneously with the firing of shots in mines in which safety-lamps were used. (In explanation of these phenomena, one of us has advanced the hypothesis that, at the instant of the passage of an INTENSE sound-wave through a Davy or Clanny lamp burning in an explosive mixture, the flame of the fire-damp is transmitted through the wire gauze by the vibratory movement of the gases, and communicated to the surrounding atmosphere. The results of a number of experiments which have been already made seem to support this view; but the series of experiments has not yet been completed.)

Two explosions (involving the loss of 108 lives) took place in mines in which safety-lamps were used and shots were fired, and one (with a loss of nineteen lives) in a mine in which naked lights were used, for the most part; but there is no evidence to show what the circumstances were under which these three occurred.

The connexion of these explosions with the changes of pressure and temperature which took place during the year 1871 will be seen by referring to Plate VII. The low pressures prevailing on January 9th and 10th were accompanied by five explosions, while the low reading recorded on the 16th produced four. From this date there is nothing particular to remark until the sudden disturbance of February 20th, which, coming

after a period of steady readings, caused as many as seven accidents, two of them fatal. The first days of March were the first warm days of the year; and so we attribute the four accidents then recorded to that cause. Several explosions which occurred during the next fortnight are referred by us to the low and unsteady state of the pressure, as are also those between the 10th and 15th of April; while the slight depression on the 29th of that month, coupled with the comparative height of the temperature, accounts for three on that day. In May we have a number of explosions for which we cannot assign a meteorological cause; and then follow a series which were mostly due to temperature, culminating in three on July 1st. The accidents at the end of June were mainly due to disturbances of pressure, which account for five. There is nothing calling for much remark until the period of the maximum temperature of the year, about August 10th, which we consider to be the cause of the four explosions then recorded. The first few days of September were warm, with a rather low barometer; and so we hold most of the accidents which then occurred to be due to meteorological conditions. At the end of the month the pressure fell very low; and we find four explosions on the 27th.

On October 13th we have three explosions, which we think were most likely due to temperature; while during the latter half of the month we have no less than fourteen cases of explosions, due to the changes of pressure which then occurred; and about the 10th of November we have four, which we attribute to the low state of the barometer.

The most striking case in the whole year was the very sudden storm which passed over the United Kingdom on the 20th of December; it was accompanied by five accidents, fortunately all non-fatal.

On the whole we have, in 1871, 207 explosions (52 of them fatal), of which 113, or 55 per cent., are due to the state of the barometer; 39, or 19 per cent., to the temperature; while 55, or 26 per cent., are not accounted for by either of these agencies.

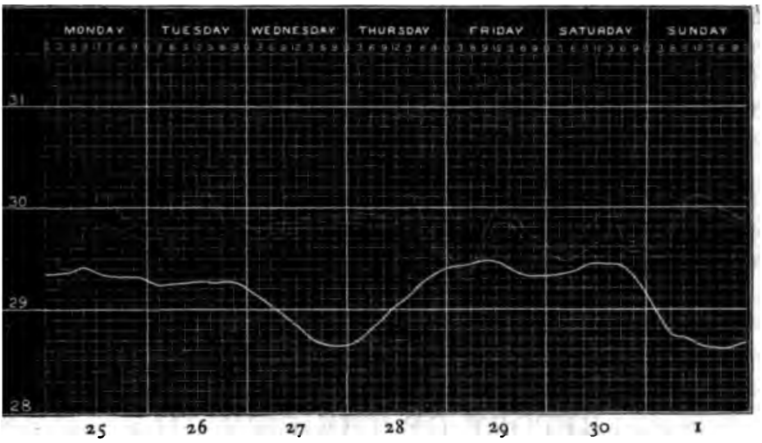
One of the general rules (26) of the Coal Mines' Regulation Act, October 1872, provides that "After dangerous gas has been found in any mine, a barometer and thermometer shall be placed above ground in a conspicuous position near the entrance to the mine." We may therefore say a few words as to the manner in which these instruments should be set up, and as to the use that may be made of their indications: we should premise, however, that they will be of most service in the case of *shallow and poorly* ventilated mines, in which the majority of slight explosions happen.

The barometer should be placed in a house, if possible, in which it is not exposed to much variation of temperature or to the sunlight, or to any artificial source of heat. The readings, to be of much service, should be made and recorded at intervals of not more than three or four hours during the day and night: corrections for height above sea-level and for temperature may be omitted.

The thermometer should be placed in the open air, in a box to the interior of which the air has free admission, at a height of 4 or 5 feet from the

und: great care must be taken to shield it from radiated or convected t, as it should register only the temperature of the air which descends mine. The readings may be made and recorded at the same time as se of the barometer; but in very warm weather they should be made ner during the hottest part of the day.

The diagrammatic method of recording pressure and temperature is the st useful one for the present purpose, as it shows the variations at a nce; the ordinates give pressure and temperature, the abscissæ the e. The following is a full-sized diagram of convenient proportions; and illustration we have plotted on it the barogram and thermogram at nyhurst, for the week ending October 1st, 1871.



The following general observations may be made regarding the indiions of these curves:—

1. If the barometric curve, after having remained about the same height several days, descends half an inch or an inch during the next two or ee days, fire-damp may be expected in greater quantity than usual in ities in the roof and in the higher parts of the workings, both during descent of the curve and for a day or two after it has reached its rest limit. Under these circumstances fire-damp may also be expected appear in some places in which it had not been seen before.

2. As the curve of temperature rises to 55° and upwards, the ventilating wer should be increased at the same time; and the higher the tempeure the greater is the necessity for such increase, in order to prevent a sible stagnation of the ventilating current.

3. If a sudden great fall of the barometer take place (an inch in enty-four hours or so), or a further fall after it has been unusually low a day or two, the utmost care will be necessary to guard against exsions, and more especially if this phenomenon be accompanied by a of temperature.

The first three and the last three months of the year are those in which most violent barometric oscillations take place.

In concluding, we may again state our opinion that the majority of explosions can be prevented by good ventilation; indeed no other conclusion can be arrived at when it is seen how much such weak agents as the meteorological changes can influence the time of their occurrence. Fire-damp would be almost unknown in many mines were a plentiful unvarying supply of air introduced and properly distributed in the workings; and in others, which cannot be safely worked without the use of safety-lamps, it would be confined within the narrowest bounds. The first step, however, towards the attainment of this object in any mine would be the introduction of an instrument to keep a constant record of the whole ventilating-power employed, natural and artificial. Such an instrument should register the quantity of air passing through the mine, *and also* the difference of pressure, reduced to the same barometric level, between the bottom of the downcast and upcast shafts; it would then show any change of the ventilating-power caused by variation of temperature above ground or neglect of the artificial means, and it would immediately detect a leakage or a stoppage in an air-course.

It is our intention on some future occasion to describe an instrument of this kind, recording Volume, Pressure, and Time, and to give an account of the result of its practical application in registering the ventilation of mines.

REPORT OF THE COUNCIL,

READ AT THE ANNIVERSARY MEETING, JUNE 18, 1873.

The Council have much pleasure in congratulating the Society, at the close of this the 23rd Session, upon the termination of a year which will bear favourable comparison with any that precedes it, whether regard be had to the character of the papers read, to the attendance at the periodic Meetings, to the number of new Fellows elected, or to the activity and interest evinced in the general proceedings. It will be observed that it was found necessary to hold an extra Meeting in the month of May, to enable all the papers which had been received to be presented before the Society; and the Council have now the gratification to announce that it is in contemplation to hold eight monthly Meetings next Session, instead of six, as has been the practice hitherto.

The number of new Fellows added to the Society during the year has amounted to 35, the accession thus indicated being considerably larger than upon any year since 1864. After a recent careful revision of the list of the Society's Fellows, and the removal from it of such names as had remained upon it without adequate reason for their retention, an operation which it is expedient to have performed from time to time, the [illegible] Fellows of the Society is found to amount to 309.

The following is a Tabular Statement of the present numerical strength of the Society:—

	Fellows.			Totals.
	Life.	Ordinary.	Honorary.	
1872, June..............	75	231	8	314
Since elected............	+2	+33	...	+35
Since compounded ...	+2	− 2	...	0
Deceased	−3	− 2	−1	− 6
Retired	...	− 7	...	− 7
Defaulters	...	− 4	...	− 4
Deceased (prior to 1872, June)	−3	− 5	...	− 8
Retired (prior to 1872, June)	...	−15	...	−15
1873, June 18	73	229	7	309

After a careful consideration of the position of the Society, so far as it is possible to determine this, the Council have reason to believe that the steady and available income of the Society at the present time amounts to £260 for the year, and that the cost of working the Society, under existing arrangements and management, is a trifle within the margin of that sum.

The Council have to announce, with considerable regret, the retirement of Mr. Glaisher from the office of Honorary Secretary of the Society, after a long period of useful and honourable service. Mr. Glaisher has performed the duties of this office since the foundation of the Society in 1850, with the exception of two years, during which he held the office of President. The Council cannot allow this retirement to take place without recording their sense of the important services Mr. Glaisher has rendered during a long life to Meteorological Science, and during nearly a quarter of a century to this Society, and of the loss which the event will entail upon the Society, although they still have the anticipation and hope of his continued cooperation with them as a Member of Council.

The Assistant Secretary, Mr. W. Marriott, has now been performing his functions as the acting residential officer of the Society during the year. In addition to his constant routine work, including his labours as sub-editor of the Quarterly Journal, he has been engaged with two special investigations of some importance. The results of one of these have been already communicated to the Society, in the form of a paper "On the Barometric Depression of January 24th, 1872." The other investigation is still in progress, and relates to the calculation of monthly mean values for some of the meteorological elements contained in the Quarterly Returns prepared by Mr. Glaisher, and issued by the Registrar-General.

It is unnecessary to state that when this discussion is complete there will be no lack of other subjects of inquiry to which this officer's attention may be advantageously directed.

The Council have deemed it desirable to appoint a Subcommittee to prepare a Form for observations for the use of the Fellows. The Report of this Subcommittee has not yet been drawn up, because it has seemed advisable to await the action of the forthcoming Meteorological Congress at Vienna, in order that the Subcommittee may avail themselves of the advantages incident to the discussions of the Congress.

The Council have to draw pointed attention to one matter in regard to the financial management of the Society. The temporary arrangement for collecting the contributions of the Society, alluded to in the last Annual Report, has been terminated; and, with the approval of the Treasurer, Mr. Marriott has been instructed to perform the functions of collector. Under this modification the cost of poundage for the collector of subscriptions will be saved to the Society.

The Council, after some consideration, have come to the conclusion that it is desirable to recommend that two alterations be made in the Bye-Laws of the Society. It has hitherto been the practice, in accordance with Bye-Law 39, to hold the Anniversary Meeting of the Society in June, although the annual accounts of the Society are made up to the 31st of December. In order that this undesirable discrepancy may be brought to an end, it is now suggested that the date of the Anniversary Meeting shall henceforth be changed to January.

The second alteration recommended is a financial matter. For several years the subscription to the Society has been fixed at £1 annual contribution, without Entrance Fee; the Life Composition being £10. The Council consider that the Society has now reached a position which warrants a return to the original practice of charging an Entrance Fee of £1 to all Fellows elected subsequently to the present time, and the change of the Life Composition, irrespective of Entrance Fee and subscriptions already paid, to £12.

The Council therefore recommend that Bye-Laws 39 and 34 shall for the future stand:—

"39. A General Meeting shall be held annually in the month of January to receive the Report of the Council on the state of the Society, and to deliberate thereon; to discuss and determine such questions as may be proposed relative to the affairs of the Society; to elect the Officers and Council for the ensuing year; and to enact, alter, or repeal any of the Bye-Laws."

"34. At least six Ordinary Meetings of the Society shall be held in each Session, the Meetings to be held in the months of February, March, April, June, November, and December; the Meetings to be held on the third Wednesday in each month," &c.

And that Bye-Laws 15 and 17 shall for the future stand:—

"15. Each Fellow shall on his election pay the sum of £1 for his Admission Fee, and if elected before the 1st of July shall pay the sum of

£1; and if elected after that date shall pay the sum of 10s. as his contribution for the current year."

"17. Any Fellow may, at his entrance, compound for his contributions by the payment of £12 (exclusive of his Admission Fee); or he may, at any time afterwards (all sums then due being first paid), compound for his subsequent annual contributions by the like payment of £12."

The Assistant-Secretary has succeeded in bringing the Library into a satisfactory condition. The preliminary steps to this end, mentioned in the last Report, have already been taken; and there are funds still in hand, out of the sale of the duplicate books, to complete the binding of all the volumes which still require it. A list of the publications received regularly during the year, in exchange for the Quarterly Journal, has been published from time to time in the successive numbers of that publication; and, in addition, the Library has received some valuable contributions, especially from Mr. Charles V. Walker, F.R.S., and Mr. G. J. Symons.

The Society has also received a valuable Robinson's Anemometer from the widow of the late Mr. F. Nunes.

The Quarterly Journal has appeared regularly, and has contained, in addition to the papers read at the Meetings, an abstract of the discussions which took place, and a few notices of recent publications of importance, &c.

The Society have welcomed with much interest the fact of the assemblage at Leipzig of a free conference of Meteorologists in August last; and as will be fresh in the memory of the Fellows, the Council set apart the Meeting in April, and the greater part of the Meeting in May, to the discussion of some of the questions which had been brought before that Conference, and to afford opportunity for the expression of the opinion of the Society thereon. The Council cannot refrain from recording here their great satisfaction at the fact that such a Conference has been organized and brought to a successful termination, and they anticipate great benefit to the science from the mutual interchange of ideas rendered possible by the personal intercourse of the several gentlemen who were present at Leipzig.

The Council, towards the conclusion of the present Session, received a letter from the Board of Trade, suggesting the nomination of a Representative of the Society at the Meteorological Congress to be held during the autumn at Vienna; and advantage was taken of the fortunate incident that its Foreign Secretary would be present at the Congress to induce that gentleman to undertake the authoritative representation of the Society at that Meeting.

In conclusion, the Council have to add to their congratulations for the present aspect of successful activity, an expression of confident assurance that the Society is steadily advancing in the path of useful work, and that it may, on that account, fairly look towards a future of continued and enlarging prosperity.

The Society has regretfully to record the loss of five of its Fellows, and one Honorary Member, by death; their names are:—

NATHANIEL BEARDMORE, F.R.A.S., elected into the Society February 1851.

EDWARD L. BETTS, elected June 1864.

FRANCIS NUNES, M.A., elected June 1870.

DAVID SLATE, elected May 1850.

AUGUSTUS SMITH, elected April 1864.

Commodore M. F. MAURY, LL.D., elected March 1852.

NATHANIEL BEARDMORE was born at Nottingham, in 1816, and died on the 24th August, 1872. From earliest youth he evinced a taste for the engineering profession, and was introduced to its practice under the guidance of the late Mr. J. M. Rendel, C.E., subsequently becoming his partner. In 1850 Mr. Beardmore brought out a work entitled 'Hydraulic Tables,' comprising a collection of tables many of which he had originally computed for his own private use. The value put on this work, and the way in which it was appreciated by the profession generally, were shown by the fact that in a very short time a second edition was called for. This edition, which was considerably enlarged and amended, was also exhausted nearly as quickly as its predecessor. Finally, in 1862, the author, anxious still more to improve and extend matter originally compiled rather in the form of notes than as an exact treatise, after collecting and collating data from every available source, published the third edition of the work under the title of 'The Manual of Hydrology.' This book is not only an acquisition to the author's own profession, but is also interesting to the meteorologist, as affording a large amount of information on the subject of rainfall and evaporation.

Mr. Beardmore was much occupied on water-questions, on which he was consulted at home and abroad. He was connected with the water-supplies of many of the large towns in the north of England. In 1846–8 he took an active part, in conjunction with Mr. Rendel and others, in the construction of the water-works at Edinburgh. He was engineer to the river Lee in Hertfordshire for upwards of twenty years. The new works, under the Act of 1851, were carried out according to his plans and designs; and he vastly improved and increased the navigation of this stream. After the passing of the Thames Navigation Act of 1866 he acted as consulting engineer to the Conservancy Board of that river. The Public Works Loan Commissioners frequently consulted him. He was constantly engaged in reporting on matters connected with hydraulic science, and in giving evidence in arbitration cases and trials at law. He gave important information before the Parliamentary Committees and before the Royal Commissioners on the water-supply of London and other large towns, and on the best means of preventing the pollution of rivers. In 1864 he reported, with the Government engineer, on the bursting of the Bradfield

reservoir near Sheffield. In 1868 he designed and constructed, in conjunction with the borough surveyor of Reading, a bridge over the Thames at Caversham.

Mr. Beardmore was elected a Member of the Institution of Civil Engineers in 1846, and was placed on the Council in 1862. The Telford Medal was awarded to him by the Council in 1854. He was elected into the Meteorological Society on February 11, 1851; and during almost the whole period from 1851 to 1872 he occupied a seat on the Council in various capacities. He held the office of President during the sessions 1861–2, 1862–3; and, on taking the chair for the first time, he delivered a very interesting address on the progress of meteorology.

Francis Nunes was the only son of Benjamin Phineas Nunes, of Llanelly, Carmarthenshire, and Farquhar House, Upper Norwood.

He was born on the 19th of January, 1842; entered at Christ's College, Cambridge, in 1861; graduated as B.A. in 1864, and M.A. in May 1868.

From his earliest years he showed a great taste for mechanics, and during several years of his too brief life took great interest in meteorology, making careful and accurate observations several times daily at his residence, Heathfield Lodge, Chislehurst, the results of which were published by Mr. Glaisher in the Quarterly Reports of the Registrar-General.

The subject, however, to which he specially devoted his attention was Solar Radiation, and the possibility of rendering observations thereof comparable. In this matter he spared neither time, trouble, nor cost. His collection of thermometers for experimenting on this subject is probably unique. It was mainly, if not wholly, through his influence that the importance of complete exhaustion in the cases of vacuum thermometers was recognized, and greater attention given to the subject by the manufacturers. The discovery of the widely varying indications produced by different amounts of exhaustion induced Mr. Nunes to contemplate the use of a solar-radiation black-bulb thermometer in a non-exhausted glass jacket; and he had a series of thermometers prepared in the autumn of 1872 to test this point. Having suffered much from the dampness of the cold season at Chislehurst, he spent the winters of 1871 and 1872 in Edinburgh. For some time he seemed to benefit by the change, and having left nearly all his apparatus at his residence in Kent, he employed himself in discussing the results he had previously obtained. He has, unfortunately, been arrested in his useful labours before his experiments were nearly completed; but he appears to have inclined towards conclusions adverse to the use of vacuum thermometers, mainly on account of the considerable differences occasionally resulting from careless manufacture.

The improvement in his health evident upon his change of residence was, unfortunately, but evanescent; his strength rapidly failed; and he finally passed away on the eve of his 31st birthday, January 18th, 1873.

Owing to his delicate health and unassuming manners few persons were aware of the extent of his knowledge, or the amount of his self-

imposed labours. His writings by no means express the measure of his successful work, his published papers being chiefly comprised in:—letters upon Solar Radiation inserted in the 'Meteorological Magazine,' edited by his friend Mr. Symons; one or two letters on exceptional phenomena inserted in 'The Times;' monthly reports contributed to a local paper; and to the returns to the Records of the Registrar-General, already spoken of.

Mr. Nunes was elected a Fellow of this Society on the 15th June, 1870; and the lively interest which he felt in its proceedings was manifest by the frequency of his attendance at the meetings.

DAVID SLATE was born at Meadowfield, a spot about five miles west of Edinburgh, on the 11th of March, 1808; and resided subsequently with his parents at Sunnyside, in East Lothian. He was educated chiefly in Edinburgh.

He had been a Fellow of the Meteorological Society from its foundation in May 1850.

By the death of M. F. MAURY * meteorological science has lost one who will ever rank among its most distinguished men. He, above all, rendered meteorology practical, and, by showing its value to the commerce of the world, induced his own Government, and subsequently those of other nations, to undertake the systematic investigation of the meteorology of the ocean.

Like many other distinguished men he was descended from French refugees and Huguenots. He was born in Spottsylvania County, Virginia, January 14th, 1806, and was, therefore, seventy-three years of age when he died. His father, a farmer, removed to Tennessee when he was four years old; and there he went to school until his 16th year, when he was transferred to Harpeth Academy, then directed by the Rev. James Otey, subsequently Bishop of Tennessee. Here his diligence and ability speedily attracted the marked attention of his superiors.

It was not until his 19th year that he obtained his midshipman's commission, and was appointed to the 'Brandywine.' Next year he was on board the 'Vincennes,' in which ship he made a voyage round the world. In 1831 he became Master of the sloop of war 'Falmouth,' on the Pacific station; and it was in this ship, on his voyage from New York to Rio Janeiro, that the idea of his Wind and Current Charts first occurred to him. His first paper was "On the Barometrical Irregularities at Cape Horn," in 'Silliman's Journal' for 1834; and at about the same time, on his return to the States, the first edition of his 'Navigation' appeared, which, emanating from so young a man (for he was not gazetted lieutenant till three years later), is a sufficient proof of the stuff that was in him. A carriage accident in 1839, by which he broke his leg and became a cripple for life, precluded him from further active service at sea, and thus gave

* Much of the substance of this notice is taken from the careful sketch of Maury's life by his friend M. de Margollé, inserted in 'La Nature,' Nos. 4 and 5.

him the leisure to prosecute those scientific studies which have been of such benefit to mankind. During the next few years his papers were numerous and various.

In 1842 he was appointed to the U. S. Naval Observatory, and soon began the preparation of his charts. The first person to act under his advice was Captain Jackson, of the 'Wright,' of Baltimore; and he succeeded in completing the double voyage to and from Rio Janeiro in about the same time as had formerly been required for the single passage out. Encouraged by this brilliant success, Lieut. Maury invited the cooperation of all navigators, and ultimately, in 1853, brought about the assemblage of the Brussels Conference, the effect of which on the subsequent progress of meteorology it is unnecessary for us here to sketch.

As for his own work, his 'Sailing Directions' reached nine editions; and his most important scientific results were embodied in his 'Physical Geography of the Sea,' a work which has also reached twelve editions.

On the outbreak of the war Maury, like so many other eminent officers, being by birth a Southerner, declared for that side. His papers &c. were destroyed by the Northern troops; and he himself was obliged to take refuge abroad. He, for a time, held the appointment of Emigration Commissioner under the unfortunate Emperor Maximilian, and resided in London; but though in considerable pecuniary distress, he steadily refused all the suggestions of employment which were made to him by this country and by Russia. On the restoration of peace he returned to his native State, where he discharged the duties of Professor of Geography at the College of Lexington until his death on February 1st of the present year.

In regard to the actual value of Maury's scientific work, it should perhaps be said that many of his conclusions were based on imperfect data, and were consequently incorrect, as was fully shown in the Report of the Committee appointed by the U. S. Government to inquire into the work of the Naval Observatory; but such must ever be the case with the pioneers of a science. If we, at the present day, reject barometrical readings for errors of hundredths of an inch, what are we to think of the instrumental records with which Maury had to deal, when the barometers were at times an inch astray? "Rome was not built in a day;" and whenever our Rome is built, and ocean meteorology raised to the rank of a science, it will never be forgotten that it was Maury who showed the quarry whence the stones were to be obtained, organized the machinery for the construction, and himself cut and laid more than one course of the foundations with his own hands.

He was elected an Honorary Member of the Meteorological Society on March 23rd, 1852.

APPEN-

Abstract of Receipts and Expenditure

Receipts.

1872.		£ s. d.	£ s. d.	£ s. d.
Jan. 1.	Balance of last year		......	161 11 9
April.	Dividend on £1000 New 3 per Cents		14 12 6	
Oct.	Do. £1100 do.		16 4 6	
	Dividends		30 17 0	
	Subscriptions for 1867	1 0 0		
	Do. for 1868	2 0 0		
	Do. for 1869	4 0 0		
	Do. for 1870	8 0 0		
	Do. for 1871	25 0 0		
	Do. for 1872	144 11 0		
	Do. for 1873	6 0 0		
	Subscriptions	190 11 0		
Feb. 19.	Composition of Capt. Toynbee	10 0 0		
Nov. 25.	Do. H. T. Hodgson, Esq.	10 0 0		
			210 11 0	
			241 8 0	
June 30.	Sales of Proceedings and Quarterly Journals	8 12 1		
Dec. 31.	Do. do.	4 5 0		
	Do. Duplicate Books	9 17 0		
	Advertisements	10 11 6		
			33 5 7	
	Receipts			274 13 7
				£436 5 4

DIX I.

for the Year ending December 31st, 1872.

Expenditure.

		£	s.	d.	£	s.	d.
1872.	Quarterly Journal, No. 1	35	12	3			
	Do. No. 2	23	9	1			
	Do. No. 3	27	5	0			
	Do. No. 4	14	3	2			
Dec. 31.	QUARTERLY JOURNAL, Four Nos.	100	9	6			
	Miscellaneous Printing, Circulars, &c.	9	18	10			
	Registrar-General's Reports	6	4	0			
					116	12	4
	Stationery 9 7 6; Post and Receipt Stamps 12 0 11	21	8	5			
	Victoria Institute, use of Rooms, ten Meetings...	13	13	0			
	Do. Attendance and Refreshments.	6	0	0			
					41	1	5
	Office Expenses, Rent, eight Months	13	6	8			
	Do. Furniture and Fittings	10	15	8			
	Do. Coals and Oil, &c.	3	1	0			
	Do. Attendance	5	8	0			
	Do. Petty Cash	0	10	3			
	Refreshments at Apartments of Civil Engineers.	1	10	6			
					34	12	1
	Assistant to Editor of Proceedings, one Quarter.	13	0	0			
	Assistant Secretary, eight Months	66	13	4			
	Collector's Commission	9	10	0			
	Bankers' Clerks at Christmas	2	2	0			
					91	5	4
	PAYMENTS				283	11	2
April 19.	£100 New 3 per Cents				91	7	6
Dec. 31.	BALANCE				61	6	8
					£436	5	4

HENRY PERIGAL, *Treasurer.*

Examined with the Vouchers, and found correct, 6 June, 1873.

W. R. BIRT, J. S. HARDING. } *Auditors*

APPENDIX II.

THE METEOROLOGICAL OFFICE. Robert H. Scott, M.A., F.R.S., Director.—The work of this Office has made steady progress during the year; the nature of this work may be most readily expressed by speaking of it under the three general heads into which it is distributed.

1. *Ocean Meteorology.*—The number of barometers afloat in merchant ships on January 1st was 98; and in addition, every ship of the Royal Navy received as usual her outfit of instruments from the Office. The total number of logs sent into the Office during the year was 125, of which more than half were distinguished by the mark of "excellent"—a proportion which, if compared with the results of former years, shows a satisfactory improvement in the character of the information returned.

The discussion of the meteorological conditions of the Atlantic Doldrums has been completed, and a specimen chart of square 3, for single-degree squares, for January, was issued to meteorologists for approval and suggestions. Nearly fifty replies were received; and, in accordance with their general tenor, the idea of publishing such charts has been abandoned; and instead of them, monthly charts of one quarter the degree of minuteness, viz. of *two degrees square*, for the same area are in process of publication. It is not intended to publish the results of all squares upon the same scale.

The investigation into the weather over the Atlantic, at the time the S.S. 'City of Boston' was lost, has been completed by Capt. Toynbee; and Anemometrical Returns for six years for Sandwick, in the Orkneys, and for four years at Bermuda, derived from the instruments erected many years ago at the suggestion of the British Association, have been published in the Quarterly Weather Report.

Investigations are in progress with reference to the Diurnal Range of the Barometer &c. between the Tropics. The observations taken in the Antarctic regions, during the expedition under the orders of Sir J. C. Ross in 1841–3, have been rediscussed, and are in the press, with the view of throwing additional light on the climate of those rarely visited regions.

2. *Weather Telegraphy.*—Eight new stations in the United Kingdom have been added to the list, including the very important one of Stornoway. The interior of England is also represented by 4 stations.

The Daily Wind and Weather Reports, which have for a long time been furnished by the telegraphic authorities to the provincial press, having been found to be unsatisfactory, arrangements have been made by which the information upon which these reports are based is now taken by the Post-Office from the Telegraphic Reports sent to the Meteorological Office.

The telegraphic network has been extended to Denmark and Sweden. A paper "On the Results of Weather Telegraphy" has been laid before the Society (p. 181). The issue of the Daily Weather Chart has been received with marked favour by the public, and upwards of 500 copies appear daily; of which about half go to subscribers—the remainder being sent free to government offices or to small seaports for exhibition to the public, and to volunteer observers. The drum is hoisted at 129 stations; and fishery barometers are erected at 118 places on the coast.

3. *Land Meteorology of the British Islands.*—The seven observatories continue to work very satisfactorily; and the staff of volunteer eye-observers has largely increased. Good progress has been made in the publication of the Quarterly Weather Report, most of the arrears being nearly cleared off. It is hoped that by the end of the year the publication, at least up to the close of the present month (June 1873), will be quite complete.

Several appendices have been issued with the successive numbers of the Quarterly Weather Reports; among which may be mentioned the Anemometrical Results to which allusion has already been made, and also the constants for Bessel's formula for the monthly march of pressure and temperature at all the observatories in 1869–70.

Mr. Scott attended the Meteorological Conference at Leipzig in August 1872, under the instruction of the Committee managing the office, and has published a complete translation of the proceedings at that Meeting.

ROYAL OBSERVATORY, GREENWICH. Sir G. B. Airy, K.C.B., P.R.S., Astronomer Royal.—No change has to be mentioned in regard to meteorological instruments, which are all in perfect order.

Some consideration is being drawn to the question whether chronographic registration could be advantageously introduced for sudden meteorological phenomena, such as shooting stars, auroral beams, &c. A small portable chronograph adapted to mechanical registration, which the observatory possesses, appears likely to be suitable for these observations.

The barometer near the front gate continues to give its indications for the public satisfactorily.

The leading features of work consist of continuous photographic records with self-registering instruments, and occasional eye-observations to determine their zeros, great attention being given to the maintenance of uninterrupted continuity in the former class. Various thermometers, pluviometers, and the standard barometer are also read at certain hours of the day, for determination of the zeros of the photographic curves.

The meteorological results are in the following state:—The eye-observations are corrected for instrumental errors, and the dew-point and degree of humidity are computed to the present time; and time-scales and new base-lines are laid down where required, to the end of 1872.

The vane of Osler's Anemometer performed, in the year 1872, 3·0 complete rotations in the positive direction N, E, S, W.

Considerable progress has been made in the reductions of the photographic records of thermometers from 1848 to 1868. The diurnal changes of the dry-bulb thermometer, as depending on the month, on the temperature waves, and on the barometric waves, have been computed and examined for the whole period; and a considerable portion of the exhibition of results is ready for press. The similar reductions for the wet-bulb thermometer are far advanced.

The usual magnetical and meteorological observations and calculations are entirely printed for 1871.

The records of the principal meteorological observations are divided into monthly groups, containing daily observations, or daily results, for barometer, thermometers (dry and wet), temperature of the Thames, winds, clouds, rain, electricity, and deep-sunk thermometers. Various monthly means, barometric waves, and entire changes of wind-direction for particular months, and for the year, are also given with these records.

KEW OBSERVATORY. Samuel Jeffery, Esq., Superintendent.—The new arrangements, which were made in 1871, having been ordered with a view to preserve continuity in the work of this Observatory, the usual course of its proceedings has been maintained without interruption.

The meteorological instruments are in good condition; and a Kew-pattern anemometer, spoken of last year as in process of testing, has appeared to work with satisfaction after the change made in the velocity part of its construction. It has been adapted so as to give an unbroken trace of velocity to the extent of 100 miles, and also to bring back the pencil hourly to the zero line.

Several anemometers, from different makers, are now on trial in open ground, which has been secured at a short distance from the building.

The number of barometers which have been tested in the year are:—marine, 103; station, 11; standard, 34; and aneroid, 14.

The number of thermometers constructed are 14 Kew standards, and tested 828 for meteorological purposes, together with 1038 clinicals.

One rain-gauge and one anemometer have likewise been tested.

Experiments are now in progress with a traveller's barometer of a new pattern, designed by Staff Commander George, of the Royal Geographical Society, with the object of providing a more safely portable mercurial barometer for those who prefer this form of instrument to aneroids for measuring heights.

There has lately been temporarily added to the duties of the staff of this Observatory the keeping of a record of temperature observations by instruments fixed at different elevations on the Pagoda in the Royal Gardens—viz. at 22·6 feet, 69 feet, and 128·10 feet from the grass level.

ROYAL OBSERVATORY, EDINBURGH. Prof. C. Piazzi Smyth, F.R.S., Astronomer Royal for Scotland.—The meteorological work here during the past year has been nearly confined to computing the observations made at 55 stations of the Scottish Meteorological Society, on a particular form, and sent to the Registrar-General of Births, Deaths, &c. in Scotland, by whom they have been printed.

The Astronomer, in a recent report to the Board of Visitors of his Observatory, remarks thus on what he has practically found to be an important influence of Meteorology in an Astronomical Observatory:—

"While the weather of last year has been to the eyes of every one so remarkable for the unusual quantity of rain, it has been to us still more memorable for the long-continued lowness as well as large fluctuations of the barometric pressure; for these circumstances have affected the rate of our best clock, the Brisbane Sidereal Clock, to so exaggerated an extent as to call for special corrections not used for years before, and to keep us in a state of intense anxiety whenever the too frequent clouds prevented star-observations being obtained for several days together.

"Scientifically the fact is noteworthy, because, after a great deal had been written by meteorologists on barometric waves as overriding, influencing, or even producing winds, temperature-changes, moisture, and almost every thing else as features of weather, it left only all the more mystery upon what produces barometric waves. And now M. von Hornstein, the Director of the Observatory at Prague, has recently demonstrated that there is a close cyclical connexion between both the absolute height and amount of fluctuation of the barometer and the period of sun-spots—that grand solar phenomenon which not only exists in spite of the philosophy of Aristotle having declared its impossibility, but is beginning to be found in the present state of science so intimately interwoven with one and another and another manifestation of either the earth or its atmosphere that man's life is never entirely free from its influences. And practically, again, the disturbance of our clock-rates by the low barometric pressure of last year is to be kept in view and profited by; for it will certainly occur again: and although instrumental corrections for such influence have hitherto been too difficult for general adoption, I am informed by the Astronomer-Royal for Ireland that a method has been perfected in Berlin, and is to be had at once for mere purchase, which can be used safely almost anywhere; in which case it does seem strange that our own, the wealthiest of all countries, 'wealthier, wealthier hour by hour,' cannot afford to let one of its Royal Observatories, largely employed in time-distribution, provide itself with such a necessary means for performing its daily work for the people with the full exactness and efficiency now rendered possible and required for the age in which we live."

RADCLIFFE OBSERVATORY, OXFORD. Rev. R. Main, M.A., F.R.S., Radcliffe Observer.—The meteorological observations at this Observatory have been carried on very much as in former years. The last published results are those for 1869; and the printing of those for 1870 will commence almost immediately, the astronomical portion of the volume for that year being completed.

The resultant direction of the wind for 1870 is 272°, or 2° north of west; while in the preceding year it was 260°. These directions are considerably further west than those which were found for the preceding maximum years of solar-spot frequency (that is, about the year 1860); and it is worthy of remark that the solar spots have been more numerous at the recently passed epoch of frequency than they were in 1870. Another confirmation is thus added to the suspicion that there is a connexion between the direction of the wind and the frequency of the solar spots.

The daily observations of the weather have been sent regularly by telegraph at 8 A.M. to the Government Meteorological Office since last midsummer.

CAMBRIDGE OBSERVATORY. Prof. J. C. Adams, M.A., F.R.S.—The meteorological work at this Observatory during the past year has been somewhat increased in consequence of the place having been selected as one of the inland meteorological stations which send daily results by telegraph to the Meteorological Office, London; Mr. Todd has undertaken to forward the necessary observations.

As the old barometer was not sufficiently accurate for the above work, a new barometer, by Adie, of London, was mounted in July; and this has been found to work well.

The usual observations at 9 A.M. and 3 P.M. have been regularly taken and reduced, and a yearly summary made out and published in the 'Cambridge Chronicle.'

The state of the sky was unfavourable for observing meteors on August 9th; but a few were observed on August 10th. It was also cloudy for the November meteors.

The College Observatory, Stonyhurst. Rev. S. J. Perry, M.A., F.R.A.S. —A complete series of meteorological observations having been carried on uninterruptedly for a quarter of a century, it was thought advisable to add to the yearly report curves of the mean annual results. The increase of rain within the last thirteen years is very apparent from the curve representing the number of rainy days. The period between the two principal maxima of the adopted temperature is eleven years, from 1857 to 1868, the minimum of solar activity occurring about 1856 and 1867. The rainfall of 1872 was less than that of 1866 by 1·1 inch; but the number of rainy days was somewhat in excess. The lowest barometer and greatest velocity of the wind also belong to 1872.

The readings of Barrow's standard barometer were discontinued in October; but five years of simultaneous observations were quite sufficient to connect the two series of barometric readings. Adie's standard is now alone read. No further alterations have been made in the meteorological instruments.

The first printed reports have been received from the new Meteorological Observatory at Zi-ka-Wei, near Shanghai. This observatory has been supplied with a complete set of magnetic instruments for the absolute measures. A similar set has just been shipped for the Meteorological Observatory at Manila.

The reduction of the photo-magnetic curves is being continued; and the results of the Magnetic Survey of Belgium have been presented to the Royal Society, and will appear in the 'Philosophical Transactions.'

Durham Observatory. John J. Plummer, Esq., Observer.—The chief aim in the direction of the meteorological work at this observatory has been to continue the series of observations commenced in 1850, without any material deviation from the original plan. Although the observations have been somewhat extended since that time, these additions are not allowed to interfere with or supersede any part of the original scheme, which is still carried out in its integrity. A secondary object has been to determine such corrections as may be requisite to render the observations throughout the whole of the twenty-three years strictly comparable. This is necessary, because the same careful adhesion to the original plan has not been displayed by the various observers who have from time to time held office. Considerable progress has been made in this important matter during the past year. An annual summary, containing the complete meteorological results of the year, together with a comparison with the mean results of the previous twenty-two years, has been compiled. This has now been the practice for several years past; and although these reports have not been printed, they are open for inspection and consultation by all interested in the meteorology of the district, and extracts can readily be made for the use of those persons who may be investigating any questions of general utility.

The whole of the instruments in use are now in perfect working order, the barometer continuing to give complete satisfaction. Careful comparisons of all the thermometers (hygrometric and self-registering) were made early in the year with the standard of the Durham Observatory; and the results show but very slight differences from previous comparisons. The anemometer (Robinson's), after having been shattered in the storm of November 6th, has been completely repaired, and is since working well. The whole of the instruments may thus be considered to be in a high state of efficiency. Readings are taken twice daily, viz. at 10 A.M. and 10 P.M. No observations by radiation thermometers have hitherto been made at Durham; but a representation of the desirability of this addition to the instruments will shortly be made to the Curators of the Observatory, and it is hoped that the want will be supplied.

British Rainfall Investigations.—The organization for the purpose of securing accurate records of the fall of rain in the British Isles has now become so established that there are somewhat fewer new features to notice than when Mr. Symons first commenced operations some fifteen years ago. But though this is the case, it neither involves nor implies that there is any reduction in the amount of work done, or in its interest and importance. On the contrary, it has become necessary to erect a special office for the storage of records and for the accommodation of the permanent assistant, who has been found to be indispensable. During the past year Mr. Symons and his assistant have been chiefly engaged in perfecting the distribution of stations throughout the three kingdoms, in revising the list published by the British Association in 1865, and, of course, latterly in examining the returns of rainfall in 1872, which have been received *perfect* from about 1700

stations, and for great part of the year from about 100 more; so that the stations in operation at the close of 1872 must have numbered nearly, if not quite, 1800.

TEMPERATURE OF THE EARTH AT GREAT DEPTHS.—In the Annual Report for 1871, and also in that for 1872, reference was made to some intended experiments to ascertain whether there are perceptible variations in the temperature of the earth at a depth of 1000 feet. Early last year a Phillips's maximum thermometer, with Sir W. Thomson's protecting shield, was specially prepared by Mr. Casella for these experiments. The instrument is about 10 inches long, and has a very short range, only 60° to 75°, and therefore a very open scale; each degree is rather more than half an inch long, and is subdivided into tenths, so that it can be easily and accurately read to 0°·01.

The Kentish-Town boring, where the experiments have been made, and where this new thermometer is to be used, was visited, and the appliances were examined by Professor Everett, the Secretary to the Underground Temperature Committee of the British Association last autumn; and shortly afterwards a copper wire was obtained for lowering the thermometer; and on October 29th, 1872, it having been set at 66°·30, it was lowered until the indicator showed that 1000 feet of wire was paid out; the boring was then plugged and left until December 23rd, when the thermometer was raised and found to read 67°·71.

Having been reset and lowered, it was left until April 5th, 1873; and then, on being raised, it was found to indicate 67°·66, or a temperature of 0°·05 lower than on the previous occasion. As there is a slight correction necessary on account of elongation of the wire by long suspension, an elongation (*i. e.* a lowering) of 1 foot producing a rise of 0°·02, Mr. Symons thinks it will be apparent, when the observations are fully discussed, that the actual difference of temperature is even less than the small amount marked in the record.

It may be interesting to add the following previous readings of other thermometers at the same depth (1000 feet):—

Six's Thermometer.		Phillips's Maximum (protected).
1869. May 14	67°·8.	1869. May 14 ...... 67°·8.
1870. January 29	67°·7.	

The fact that all these values agree within two tenths of a degree, Fahrenheit, speaks well both for the mode of observation and for the instruments.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

JUNE 18th, 1873.

Ordinary Meeting.

JOHN W. TRIPE, M.D., President, in the Chair.

NATHANIEL ST. BERNARD BEARDMORE, 30 Great George Street, S.W.; ROBERT HENRY COOKE, 6 Belmont Road, Clapham, S.W.; JAMES GARTH MARSHALL, M.A., F.G.S., Headingley House, near Leeds; and W. W. RUNDELL, Litherland Park, near Liverpool, were balloted for, and duly elected Fellows of the Society.

The name of one Candidate for Admission into the Society was read.

The following papers were then read:—

"On some Results of Temperature Observations at Durham." By John J. Plummer (p. 241).

The PRESIDENT said that there was one point in the paper which the Meeting could not discuss that evening, viz. as to the best form of thermometer-stand; and he would therefore postpone the discussion of that subject to the first Meeting of next Session.

Mr. GASTER promised that his portion of the discussion of the experiments with the different thermometer-stands made at Strathfield Turgiss should be ready by that time.

Mr. GLAISHER said that the tables of corrections for diurnal range were based upon seven years' two-hourly observations at the Royal Observatory; and he believed that at most stations where observations were carefully made, and the

results properly corrected by the tables, they would agree very closely with the true mean temperatures. The photographic records at the Royal Observatory for twenty-one years were being reduced; and he had no doubt that when they were completed more accurate tables could be obtained. He hoped that the results from the self-recording stations of the Meteorological Office would furnish the data for the best diurnal range tables for different parallels of latitude. He thought that the diurnal range tables were quite as accurate for Durham as they were for Greenwich.

"On the Meteorology of New Zealand in 1872." By Charles Rous Marten, F.M.S. (Abstract.)

The meteorology of New Zealand was remarkable in the year 1872 on account of the exceptionally great heat and dryness at the beginning and end of the year, and also on account of the unusual heavy snow-storms of the winter.

The highest temperatures in the shade were recorded at Christchurch, 43° S. lat.; and were, for January 95°·7, February 94°·1, and December 92°. Temperatures of 94° and 92° were recorded at Napier.

The highest readings in the sun were:—Nelson (41° S. lat.), 185° at the Observatory (194° at another part of the town); Dunedin (45° S. lat.), 180°; Southland (47° S. lat.), 162·2°,—all records from insulated black-bulb thermometers *in vacuo*.

The lowest temperatures for Bealey, 2104 feet above the sea, were:—June, 12°·0; July, 13°·0; at Southland, June, 17°·0.

A S.W. gale occurred at Wellington in the middle of April, with a flood, the month's fall of rain amounting to 11·66 inches.

Snow-storms extended throughout the islands in June and July, the snow becoming hail in the central districts, and rain in the north. The snow was most heavy in the south-west. There were also August snow-storms in the Middle Island; they were of five days' durations in Canterbury, Otago, and Southland. Snow occurred in Southland as late as September 27th, and at Queenstown as late as December 3rd.

There were remarkable auroræ in Southland on January 9th, February 1st (seen over the whole colony), August 9th, and October 17th. Slight shocks of earthquake were experienced in February, March, November, and December.

Rain set in in Southland on the 9th of June with a falling barometer, and on the following day changed to snow, which then continued to fall heavily for five days, attaining a depth of 15 inches, altogether unprecedented in the country. There was severe frost and much thunder and lightning, with squalls from the west, varying at first to W. by N., and subsequently to W. by S. The barometer fell steadily to 28·900 in. on the 11th, and 28·779 in. on the 12th, and then gradually rose. The snow ceased on the 15th, with 9 inches remaining on the ground, and with a maximum temperature in the shade for the day of 28°, the lowest maximum recorded for fourteen years. Easterly winds and hard frost continued until the 24th, when thaw set in, with thick fogs, lasting to the end of the month. At Hokanui, thirty miles north of the Observatory, and in the interior, the snow only amounted to 2 inches.

At the Southland Observatory for this month of snow-storms (June) the mean atmospheric pressure, by barometer, corrected and reduced, was 29·599 in.

Maximum pressure	30·129 in.
Minimum pressure	28·779 in.
The temperature of air, mean ..	38°·8
Maximum	67°·0
Minimum	17°·0
Daily range	13°·1
Maximum in sun	81°·5
Minimum on grass	14°·0
Dew-point	36°·0
Humidity	·91
Maximum daily rain	1·25 in.

Prevailing winds N., N.W., and S.E., with mean velocity of 124·4 miles.

Much snow fell also in the months of July and August, although in less quantity. The snow-storms of these later months were more protracted and severe in Otago and Canterbury than in Southland.

A table of monthly temperatures and rainfall for thirteen stations in New Zealand, for the year 1872, is communicated for the Library of reference of the Society.

The PRESIDENT said that he did not invite discussion that evening, as the Annual General Meeting was to take place after the Ordinary Meeting, and because there was a great deal of business to get through.

"On the Climate of Vancouver Island." * By Robert H. Scott, F.R.S.

"Meteorological Observations at Zi-Ka-Wei, near Shanghai." By Rev. A. M. Colombel; with note by Rev. S. J. Perry, F.R.A.S. (Abstract.)

The Rev. S. J. Perry reports that a first step has been set to establish a permanent Meteorological Observatory at Zi-Ka-Wei, near Shanghai. The Rev. A. M. Colombel, the Resident Director of the observatory, promises to send a full description of the observatory and instruments at the end of the year; and in the mean time Mr. Perry communicates, for the Library of reference of the Society, tables comprising daily records of air-pressure, air-temperature, humidity, and direction of the wind for the months of December, January, and February last.

"Notes on the Connexion between Colliery Explosions and Weather in 1871." By Robert H. Scott, F.R.S., and W. Galloway (p. 246).

"Distribution of Rainfall Maxima in Great Britain and Ireland between the years 1848 and 1872 inclusive." By William R. Birt, F.R.A.S. (Abstract.)

In the volume of British Rainfall for 1872 Mr. Symons gives a table of the quantities of rain collected at eighty-two stations in Great Britain and Ireland for the years of large rainfall—1848, 1852, 1860, and 1872—with the excess in 1872 above the mean of the years 1860–69. In Mr. Birt's paper these quantities are arranged in descending order from the large fall at Seathwaite of 182·58 inches in 1861 (the year 1872 giving 182·58 inches) to the smallest maximum recorded within the last twenty-five years. From this arrangement of Mr. Symons's data Mr. Birt points out that the excess of rainfall was greatest in the western part of Great Britain, diminishing towards the east.

"Note on the Heavy Rainfall at Natal on March 4th, 1873." By Robert James Mann, M.D., F.R.A.S.

Rain fell at Durban, the seaport of Natal, on the night of March the 4th, so heavily that the record for the night between the evening of the 4th and the morning of the 5th amounted to 6·50 inches. This is the heaviest fall on record in the colony, with the exception of that of the flood of April 15th, 1856 (see 'Proceedings' of the Society, April 1868, p. 153), when the fall was 11·93 inches within twenty-four hours. The barometer stood at 30·070 in., a few feet above the sea-level, at 9 A.M. on April 29; on March 2, 9 A.M., it stood 30·244 in; on March 3, 9 A.M., it stood 29·934 in.; March 5, 9 A.M., it stood 30·214 in.

The Meeting was then declared closed.

* The abstract of this paper will appear in the next number.

Donations received from April 1st to September 30th, 1873.

Presented by Societies, Institutions, &c.

Brussels	Observatoire Royal	Annales, January to March 1872, February and March 1873.
	"	Résumé des observations sur la Météorologie et sur la Physique du Globe, 1871. By M. Ad. Quetelet, Director.
Christiania	Kongelige Norske Universitet.	Die Pflanzenwelt Norwegens. Ein Beitrag zur Natur- und Culturgeschichte Nord-Europas. Von Dr. F. C. Schubeler.
	Norske Meteorologiske Institut.	Meteorologisk Aarbog, 1871. By Professor H. Mohn, Director.
Copenhagen ...	L'Institut Météorologique Danois.	Observations at various stations, March to August 1873. By N. Hoffmeyer, Director.
Cracow	K. K. Sternwarte	Meteorologische Beobachtungen, January to August 1873. By Dr. F. Karlinski, Director.
Dublin	Royal Irish Academy	Proceedings, vol. x. part 4; series 2, vol. i. nos. 2–8.
	"	Transactions, vol. xxiv. parts 16, 17; vol. xxv. parts 1–4.
Edinburgh	Scottish Meteorological Society.	Journal, New Series, nos. 36–39.
Fiume	I. R. Accademia di Marina	Meteorological Observations, January to May 1873.
Geneva	Société de Géographie	Le Globe, tome xi. livraisons 4–6.
Hobart Town ...	Royal Society of Tasmania.	Results of five years' meteorological observations for Hobart Town; with which are incorporated the results of twenty-five years' observations previously published, and completing a period of thirty years.
Klagenfurt	Observatory	Meteorologische Beobachtungen, January to August 1873. By Dr. J. Prettner, Director.
Liverpool	Literary and Philosophical Society.	Proceedings, no. 26.
London	Army Medical Department	Reports for the years 1866–71. By Sir T. G. Logan, K.C.B., M.D., Director-General.
	Brazilian Legation	Climats, Géologie, Faune et Géographie Botanique du Brésil, par Emmanuel Liais. By the Brazilian Minister.
	General Register Office ...	Quarterly Return of Marriages, Births, and Deaths, June 1873. By the Registrar-General.
	London Institution	Journal, nos. 20, 21.
	Meteorological Office	Daily Weather Report, January 1 to April 30, 1872, and April 1 to September 30, 1873.
	"	Quarterly Weather Report, 1871. Part iii. 1872. Part iii.
	"	Report for the year ending December 31, 1872.
	"	Contributions to our knowledge of the Meteorology of the Antarctic Regions. By the Meteorological Committee.

London	Royal Institution	Proceedings, nos. 57, 58.
	Royal Society	Proceedings, nos. 143–146.
	Society of Telegraph Engineers.	Journal, vol. i. no. 3.
Lyons	Commission Météorologique	Résumé des observations météorologiques faites à l'Observatoire de Lyon, par M. Lafon, Directeur, 1870.
Manchester......	Literary and Philosophical Society.	Proceedings, March 18 to April 15, 1873.
Mauritius	Meteorological Society......	Proceedings and Transactions, vols. v., vi.
	"	Monthly Notices, October, November, December 1872; January, February 1873.
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Oxford............	Radcliffe Observatory	Results of Meteorological Observations, 1870.
	"	Observations of Shooting Stars, 1872. By Rev. R. Main, F.R.S., Radcliffe Observer.
Paris	Observatoire National	Bulletin International. By M. U. J. Le Verrier, Director.
	Observatoire Physique Central de Montsouris.	Bulletin Mensuel, nos. 1, 2, 6, 8, 13–19. By M. Marié Davy, Director.
Philadelphia ...	American Philosophical Society.	Proceedings, no. 89.
Rome	Ministerio di Agricoltura, Industria e Commercio.	Meteorological Observations at various stations, January to March 1873.
	Osservatorio del Collegio Romano.	Bullettino Meteorologico, March to June, August 1873. By Padre Secchi, Director.
St. Petersburg...	Central Physical Observatory.	Annalen, 1871. By M. H. Wild, Director.
Sydney	Observatory	Meteorological Observations made at the Government Observatory, Sydney, during October 1872 to March 1873.
Toronto	Education Office	Journal of Education, January to August 1873. By Rev. E. Ryerson, D.D.
	Magnetic Observatory	Second Report of the Meteorological Office of the Dominion of Canada. By G. T. Kingston, M.A., Director.
Utrecht	Royal Dutch Meteorological Institute.	Suggestions on a Uniform System of Meteorological Observations.
	" " ...	A Sequel to ditto.
	" " ...	Nederlandsch Meteorologisch Jaarboek, 1867, parts 1, 2; 1868, 1, 2; 1869, 1, 2; 1870, 1; 1871, 1; 1872, 1. By M. Buys Ballot, Director.
Vienna............	K. K. Centralanstalt für Meteorologie und Erdmagnetismus.	Beobachtungen, January to August 1873.
	" "	Jahrbuch, 1870. By Dr. C. Jelinek, Director.
	Oesterreichische Gesellschaft für Meteorologie.	Zeitschrift, Band vi., Band viii., nos. 1–10, 12–17.
Washington ...	Office of the Chief of Engineers.	On the Use of the Barometer on Surveys and Reconnnaissances, by Major R. S. Williamson.
	" " ...	Practical Tables in Meteorology and Hypsometry, by Major R. S. Williamson. By the Chief of Engineers.
	Smithsonian Institution ...	Reports for the years 1858 and 1859. By Professor J. Henry, Secretary.

Presented by Individuals.

Barham, C., M.D.	Remarks on the Meteorology of Cornwall, 1864–67, 1869–72.
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Forbes, Duncan	Report on the unusual intensity of the frost of December 1860 and January 1861, with its injurious effects on trees, shrubs, pines, &c.; and a comparison between the great cold of this period and that experienced in the severe winters of 1837–8, 1841, and 1855; with some remarks on the intense frost of January in the present year (1867). By Duncan Forbes.
Hall, J. J.	'The Horological Journal,' November and December 1872.
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Mackenzie, J. I., M.B.	Remarks on the Climate of Sidmouth; with tables giving the results of Meteorological Observations. By J. I. Mackenzie.
" "	The Climate of Sidmouth; with results of Meteorological Observations from 1865 to 1870. By J. I. Mackenzie.
" "	Seven Years' Meteorology of Sidmouth, 1865–71. By J. I. Mackenzie.
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Negretti and Zambra	Encyclopædic Catalogue of Meteorological and Scientific Instruments.
"	Treatise on Meteorological Instruments.
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"	Temperature of Brighton.
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"	Symons's British Rainfall, 1869, 1871, 1872.
"	British Association Reports of Rainfall, 1867–71.
"	Madras Meteorological Observations, 1841–50.
"	A General View of the Natural History of the Atmosphere. By H. Robertson, M.D.
"	Sur le Tonnerre en Éthiopie, par Antoine D'Abbadie.
"	'The Horological Journal,' 1863.
"	Sur les Étoiles Filantes, par E. Herrick et A. Quetelet.
"	Abstract of Observations on the Aurora, Cirri, &c., made at Dunse. By William Stevenson.
"	Report on the Meteorology of Scotland during the quarters ending December 1856, March and December 1857, March, June, and September 1858, June 1859.
"	Quarterly Report of the Meteorological Society of Scotland, December 1860, December 1861, December 1862, March and June 1863.

Symons, G. J.	Supplement to the Monthly and Quarterly Returns of the Births, Deaths, and Marriages registered in Scotland during the year 1872.
"	A Treatise on Meteorology. By A. J. T. Morris.
"	The Shepherd of Banbury's rules to judge of the changes of the Weather.
"	The Influence of Climate in the prevention and cure of Chronic Diseases. By James Clark, M.D.
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"	Dent on the Dipleidoscope.
"	The foretelling of the Weather in connexion with Meteorological Observations. By F. H. Klein and Prof. Buys Ballot.
"	Report of the Astronomer to the Marine Committee, Mersey Docks and Harbour Board, 1863.
"	Monthly Meteorological Tables for the year 1856. By H. Allnutt.
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"	'Food Journal,' nos. 39–44.
"	'Nature,' nos. 160, 179–204.
"	'Public Health,' nos. 1–4.
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" "	Signal-Service Weather Reports. By P. E. Chase.
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" "	The Meteorology and Climate of Plymouth. By John Merrifield, Ph.D.
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" "	Magnetic Survey of the East of France in 1869. By Rev. S. J. Perry.

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